

Session 3:

MAGNETIC FIELD WINDS AND OUTFLOWS

The magnetized halos of spiral galaxies



Ralf-Jürgen Dettmar
Astronomical Institute
Ruhr-University Bochum

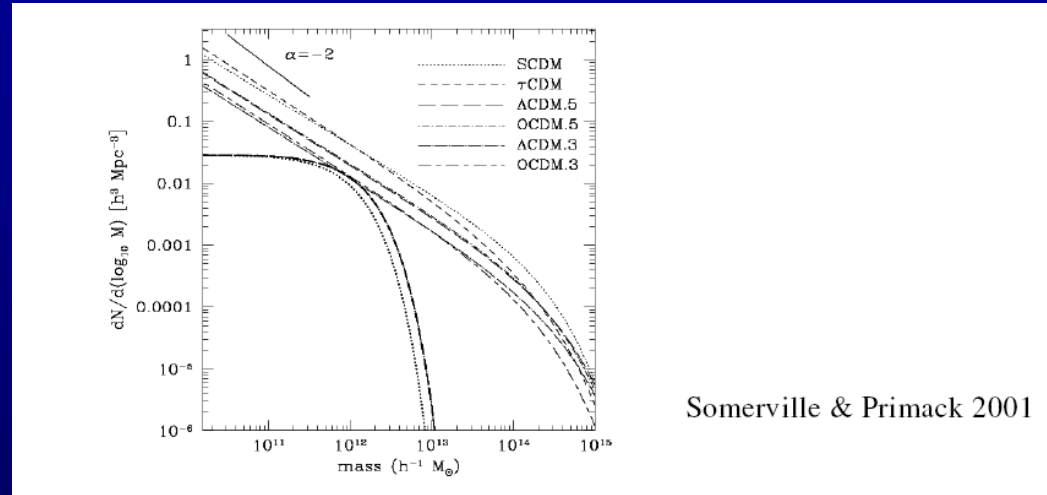
collaborators in this field are (random order):

- J. Rossa (†)
- R. Tüllmann/ now CfA
- V. Heesen/ now Hatfield
- G. Heald / ASTRON
- M. Urbanik & M. Soida/ Krakow
B. Adebahr & M. Wezgowiec / Bochum
- Y. Shcheckinov / Rostov
- M. Dahlem / now Muscat
- M. Krause & R. Beck / MPIfR
- M. Ehle /ESA-ESAC



Why do we care about the (magnetized) ISM in galactic halos?

The role of feedback in structure formation (and magnetizing the IGM/ISM)



Chemical evolution of the ISM/IGM

Large scale structure of the magnetic field in galaxies

Dynamo theory, e.g. the helicity problem

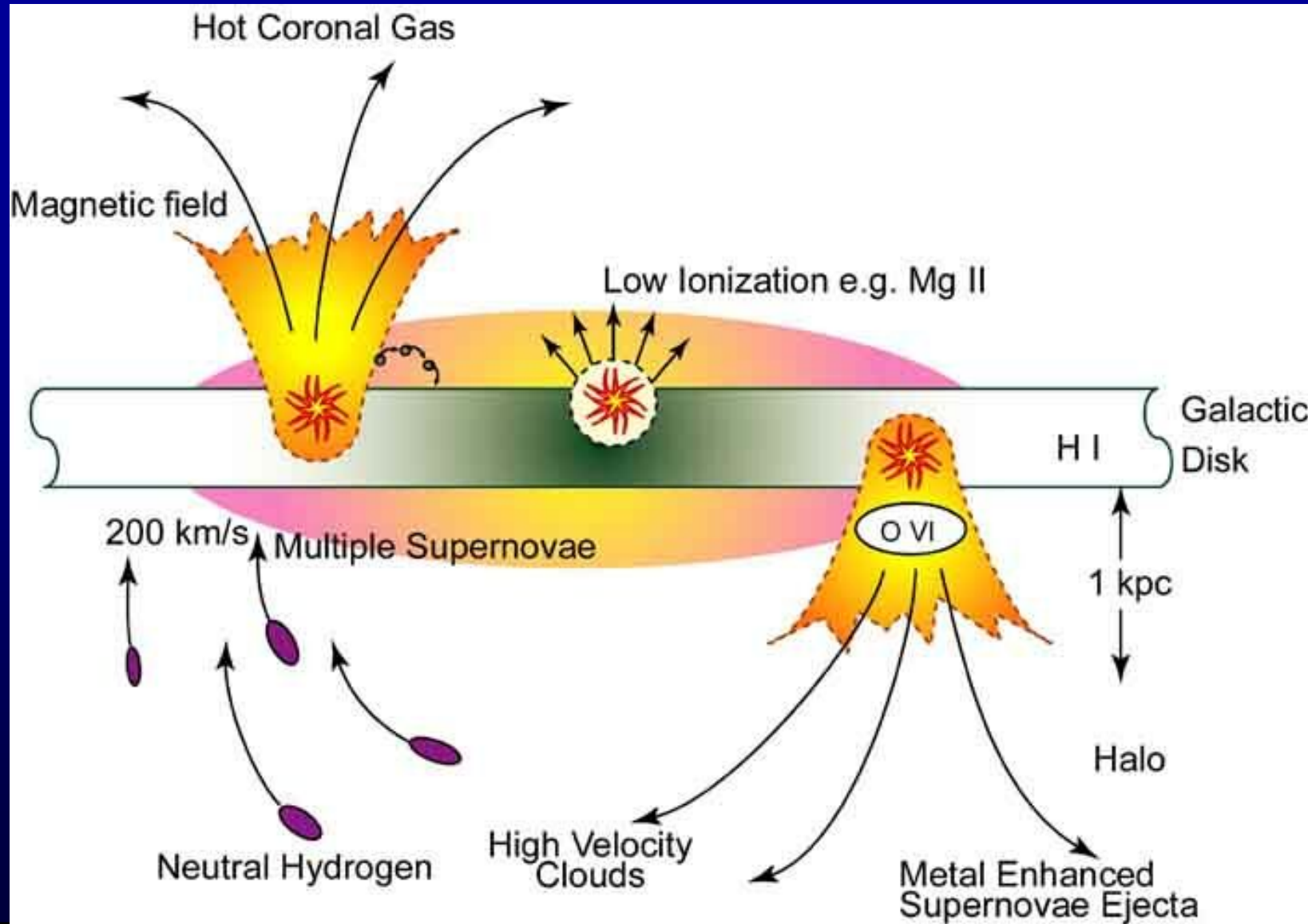
Magnetized halos of spiral galaxies

Ralf-Jürgen Dettmar @ MFPO2010



SN driven ISM

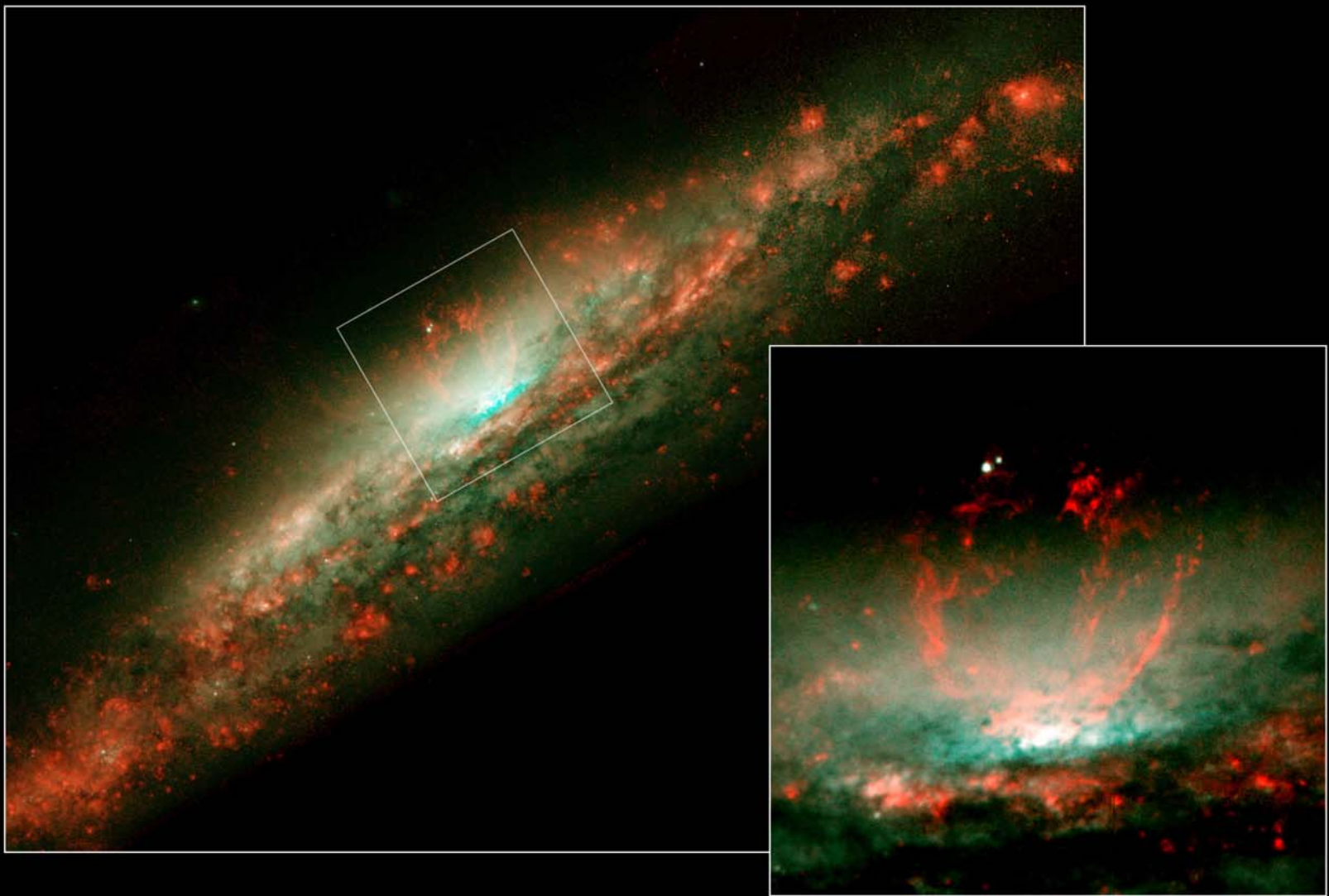
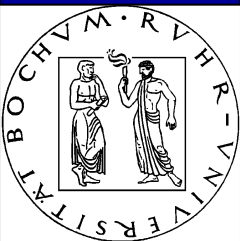
we saw D. Cox's drawing yesterday, here: unknown NASA artist



Magnetized halos of spiral galaxies

Ralf-Jürgen Dettmar @ MFPO2010





Galaxy NGC 3079
Hubble Space Telescope • WFPC2

NASA and G. Cecil (University of North Carolina) • STScI-PRC01-28

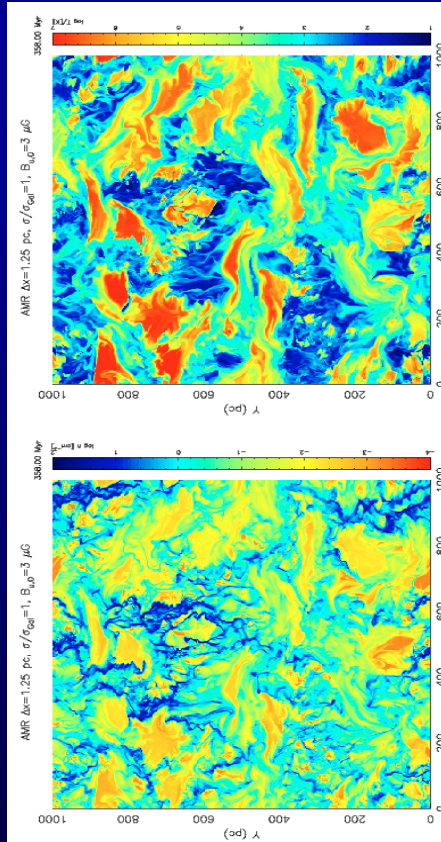
Magnetized halos of spiral galaxies

Ralf-Jürgen Dettmar @ MFPO2010

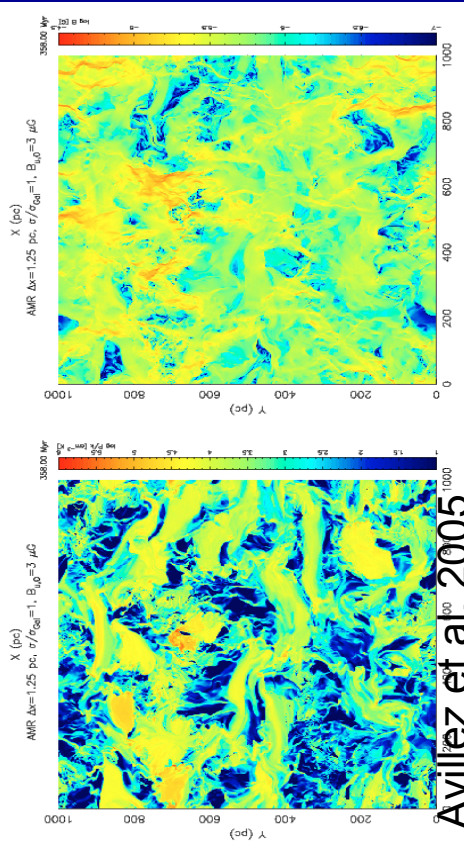


view from top

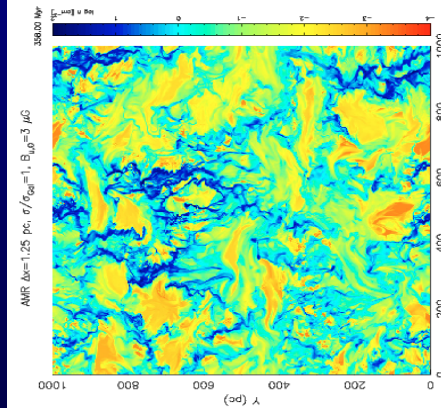
Density



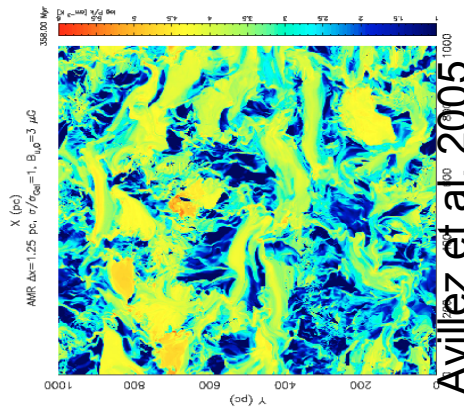
Temperature



Pressure



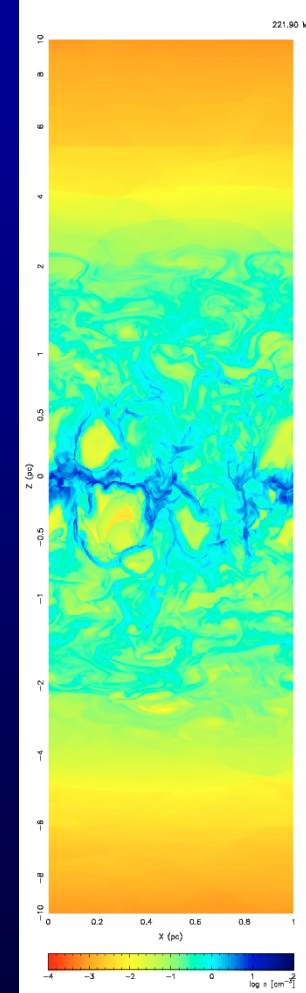
Magnetic Field



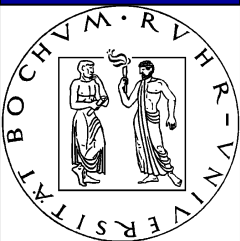
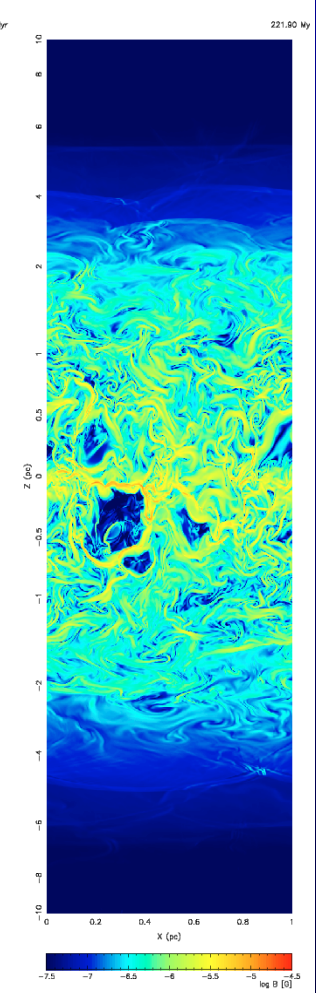
Avillez et al. 2005

view from side

Density



Magnetic Field



Magnetized halos of spiral galaxies

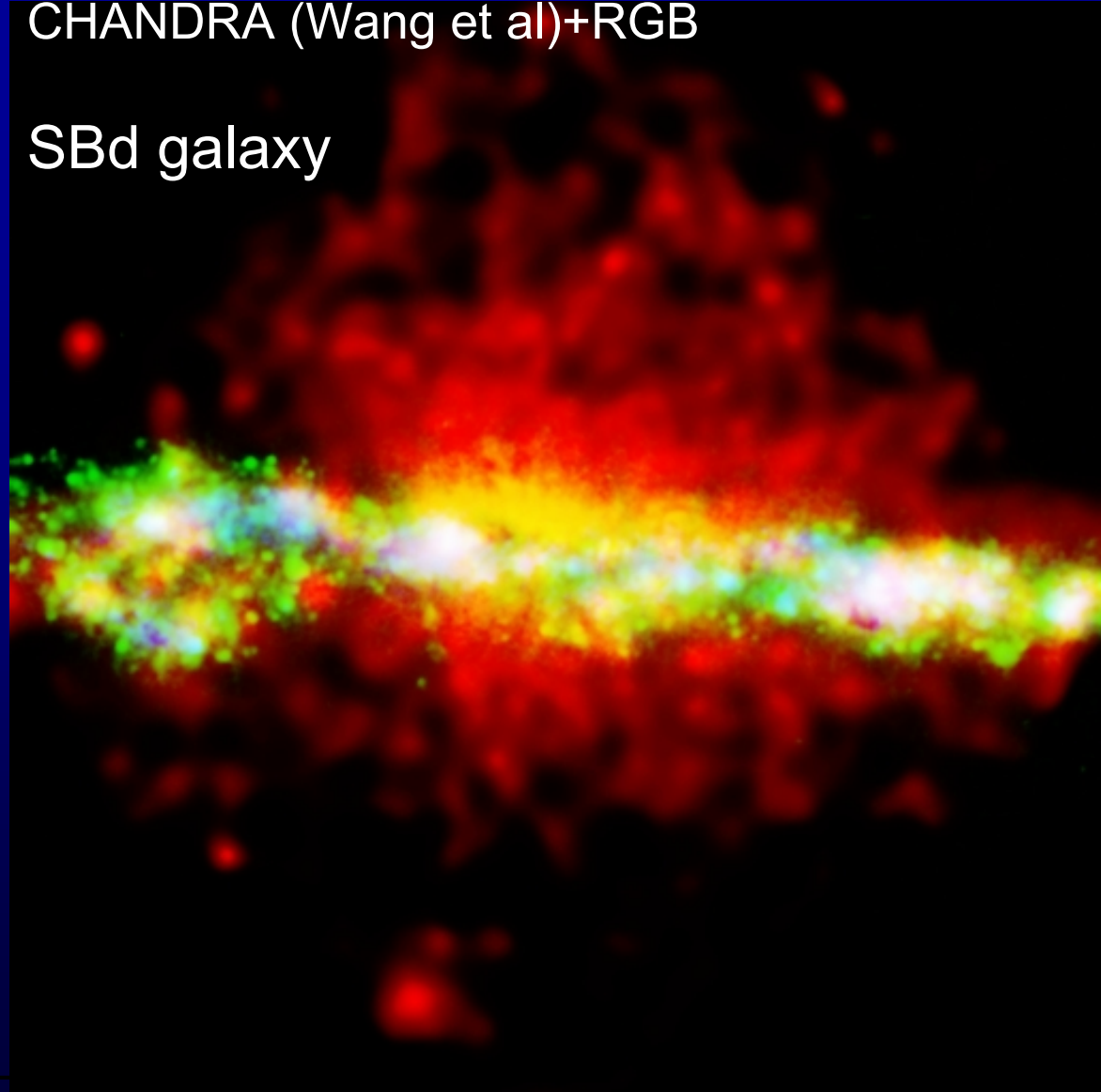
Ralf-Jürgen Dettmar @ MFPO2010

May 18, 2010

NGC4631 multiwavelengths obs.

CHANDRA (Wang et al)+RGB

SBd galaxy

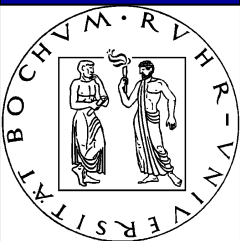
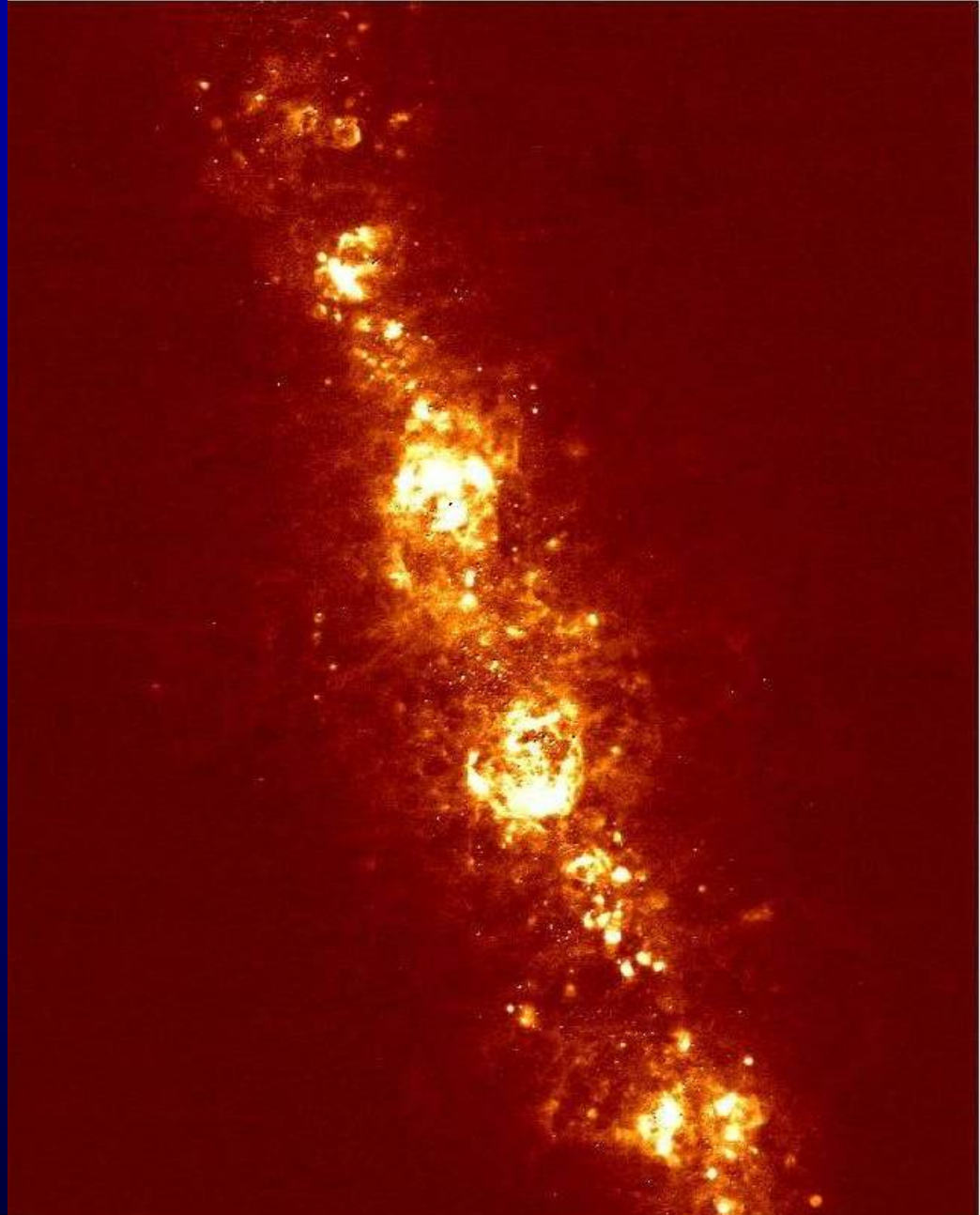


Magnetized halos of spiral galaxies

Ralf-Jürgen Dettmar @ MFPO2010

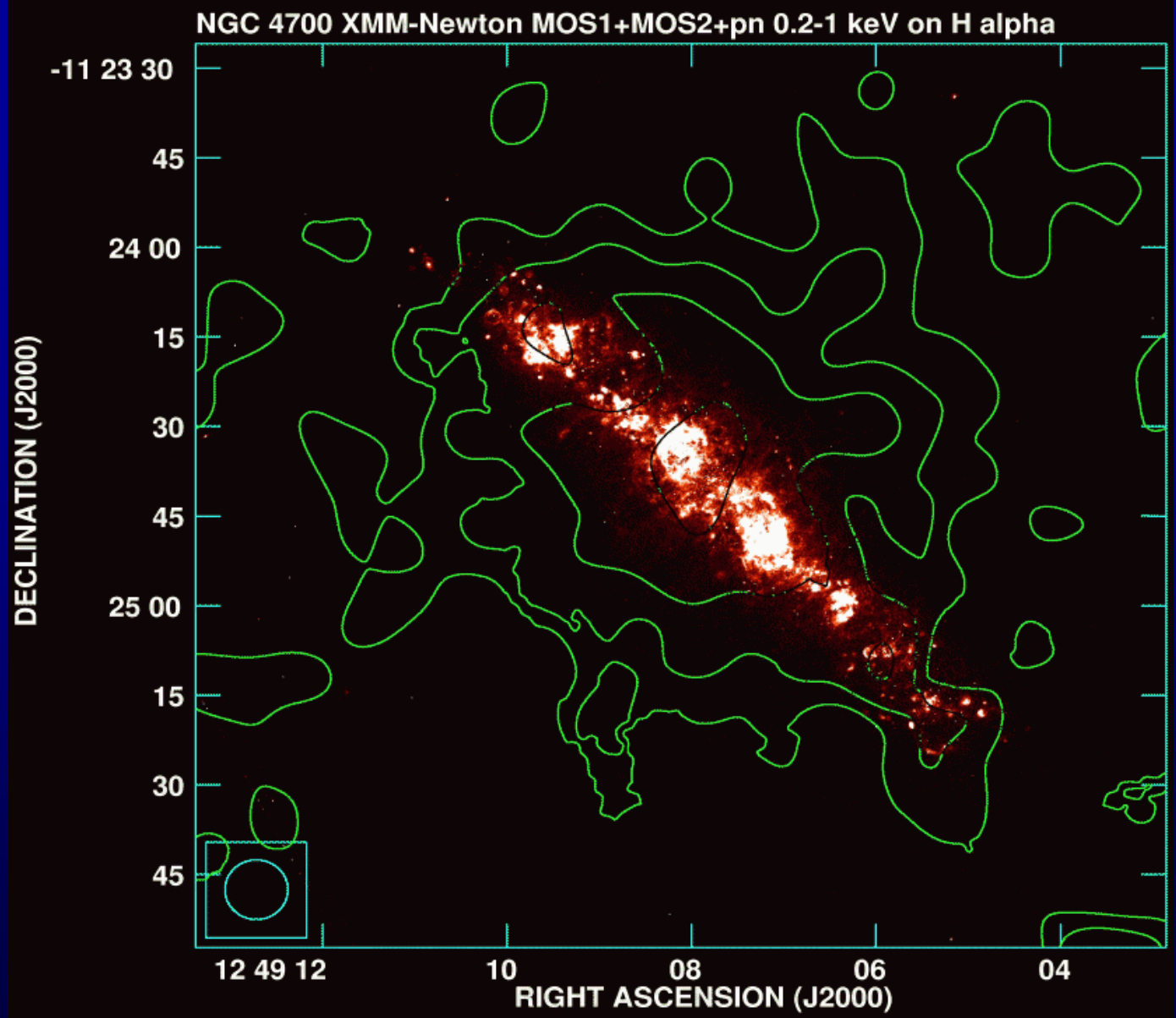
NGC4700 HST/ACS

(Rossa, Dahlem, Dettmar,
van der Marel, AJ submitted)



Magnetized halos of spiral galaxies

Ralf-Jürgen Dettmar @ MFPO2010

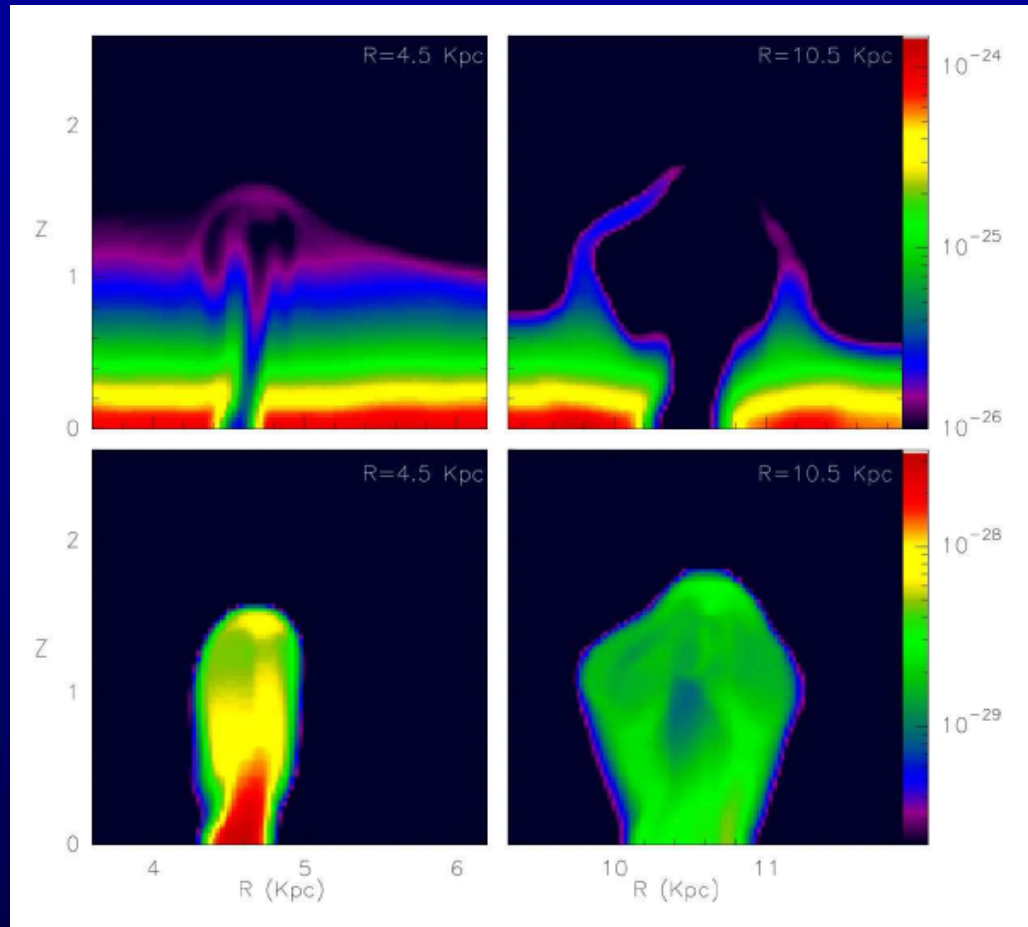


Dettmar, Wezgowiec et al.

Magnetized halos of spiral galaxies

Ralf-Jürgen Dettmar @ MFPO2010

SN driven fountain not sufficient

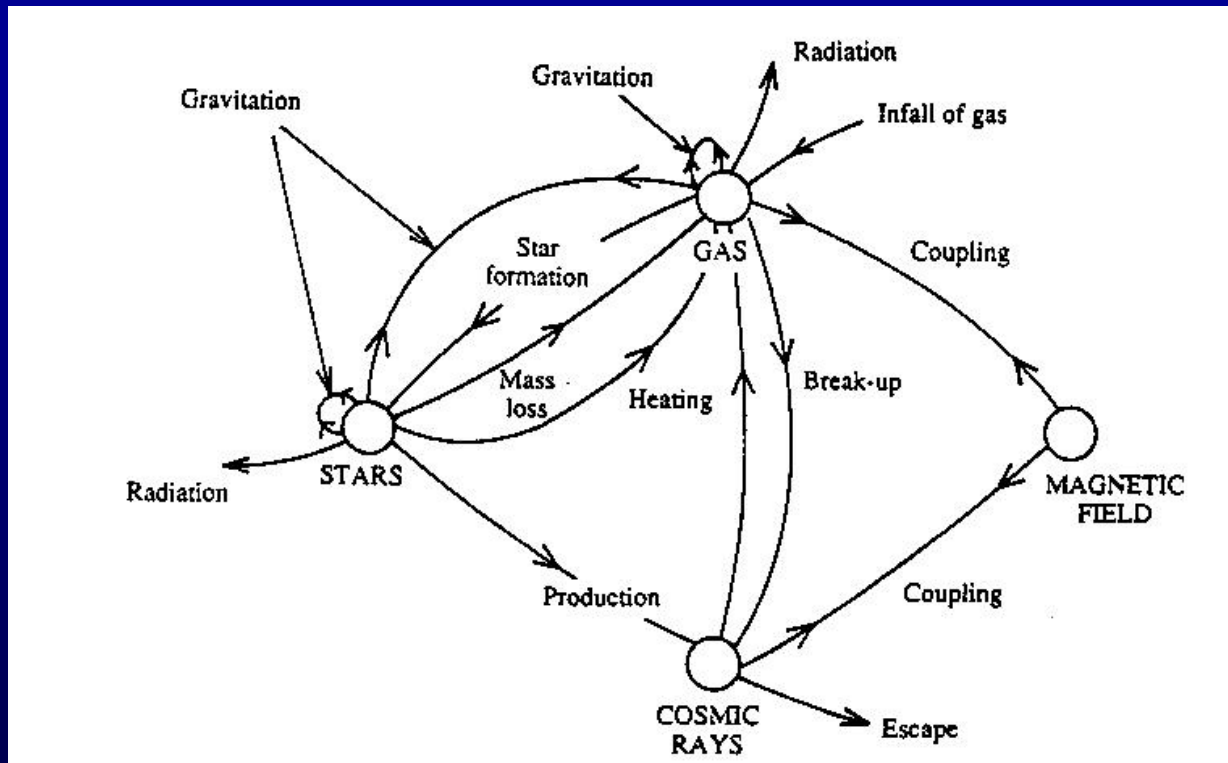


Melioli, ..., Dal Pino et al. MN 2008

Magnetized halos of spiral galaxies

Ralf-Jürgen Dettmar @ MFPO2010

(from Taylor, Cambridge Univ. Press)



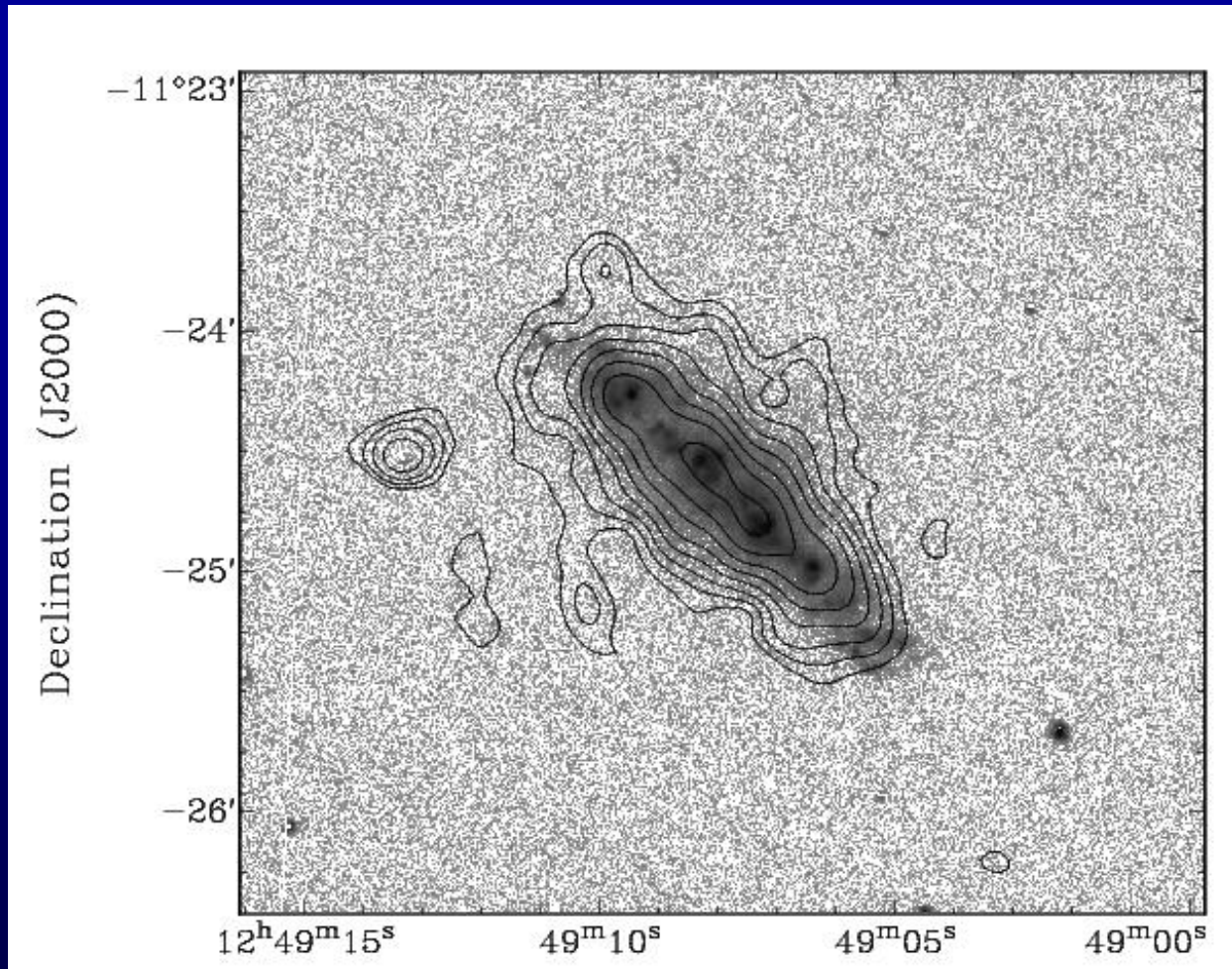
Magnetic Fields and Cosmic Rays contribute significantly to the energy density

Magnetized halos of spiral galaxies

Ralf-Jürgen Dettmar @ MFPO2010



NGC4700 21cm continuum

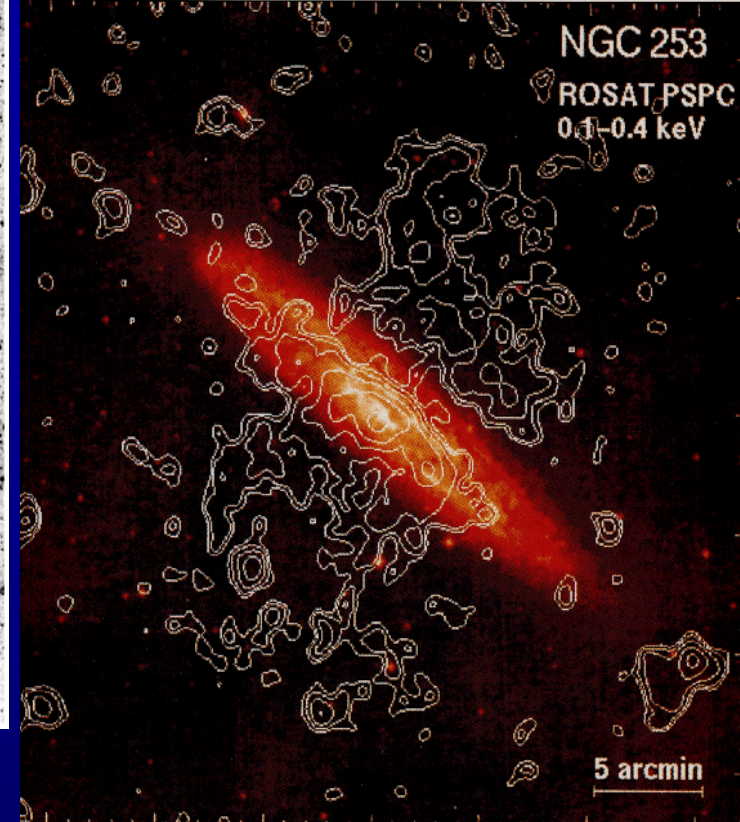
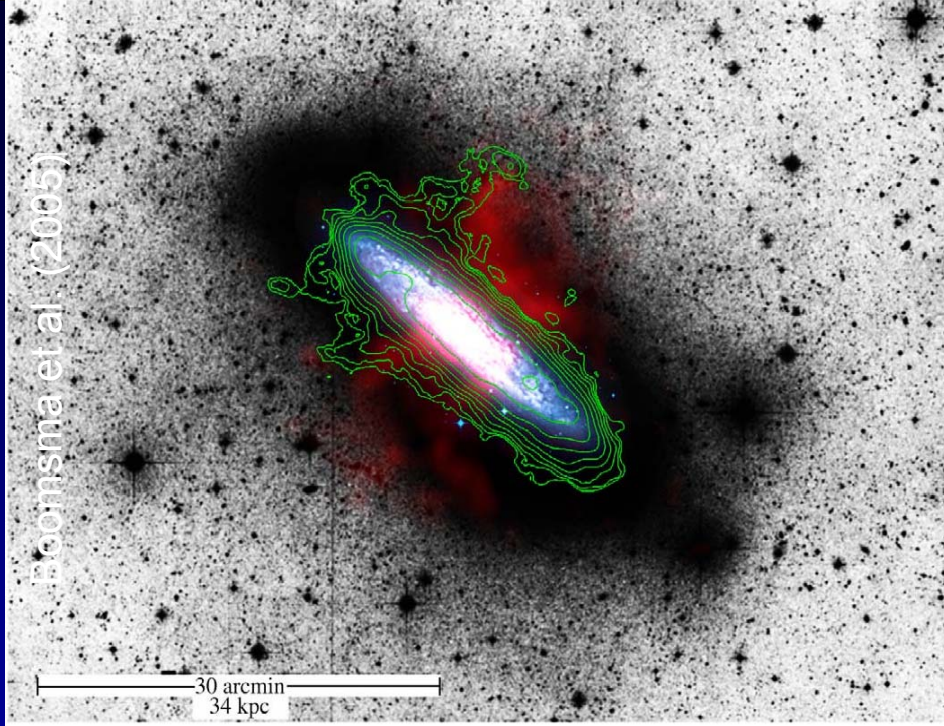


from Dahlem et al.



Magnetized halos of spiral galaxies

Ralf-Jürgen Dettmar @ MFPO2010

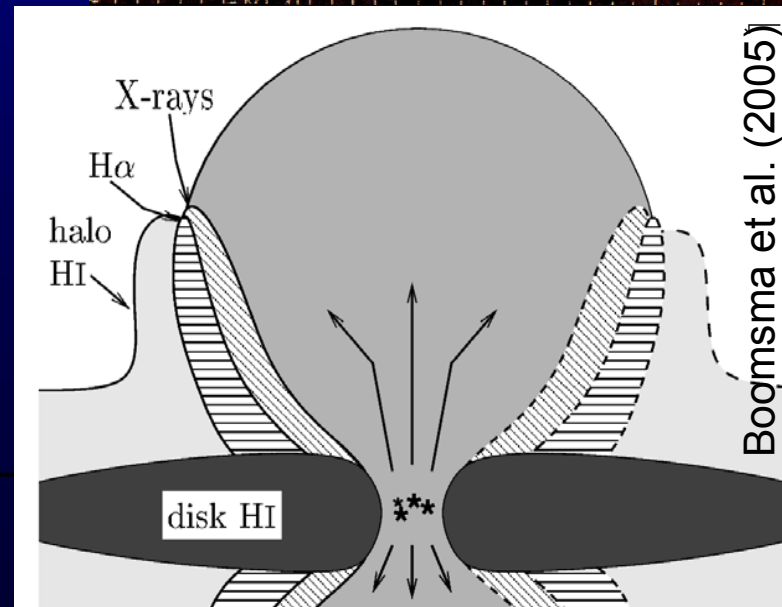


Halo of NGC 253:

- X-ray emission
- $H\alpha$ emission
- HI emission
- radio continuum emission

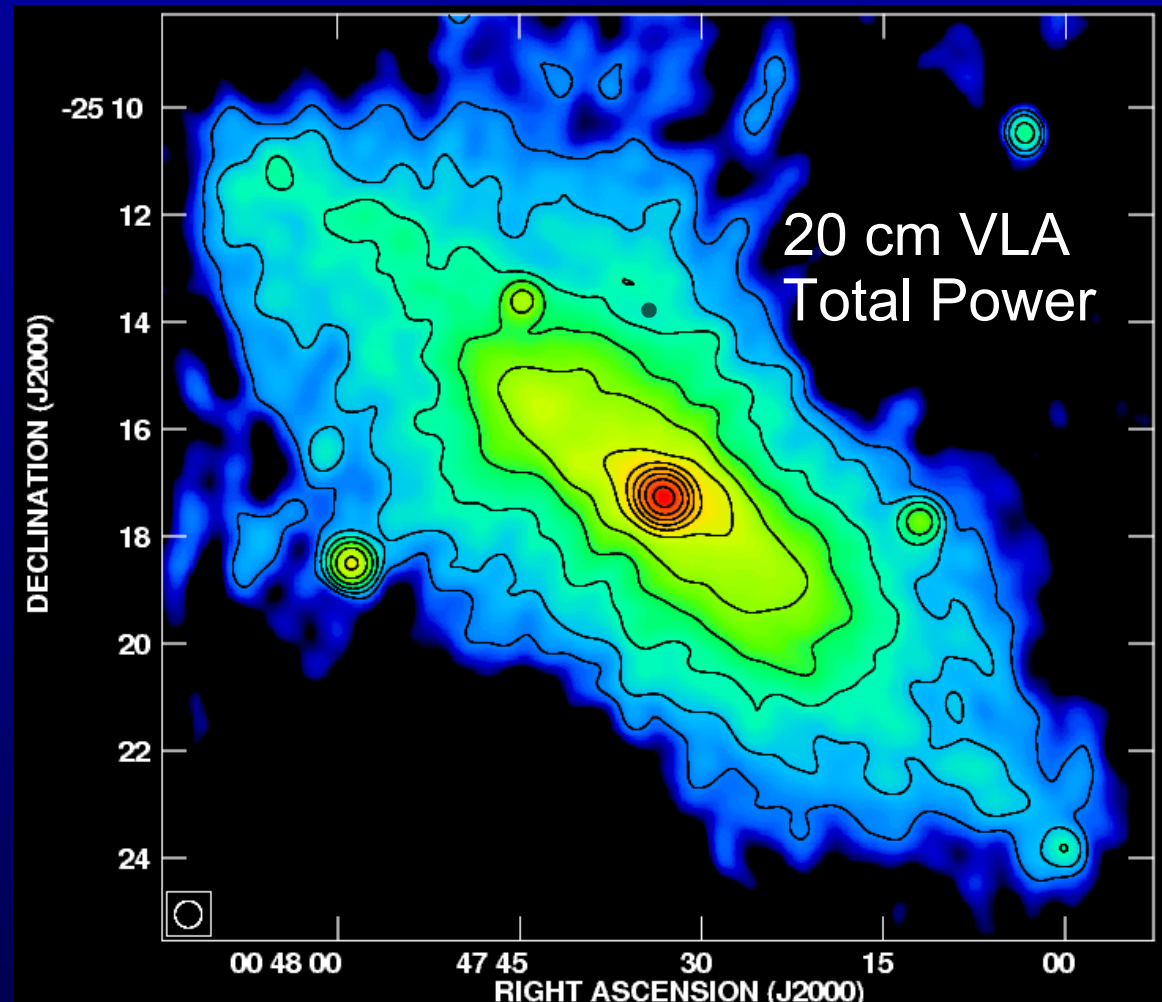
Magnetized halos of spiral galaxies

Ralf-Jürgen Dettmar @ MFPO2010



NGC253

Heesen et al.
2009



Magnetized halos of spiral galaxies

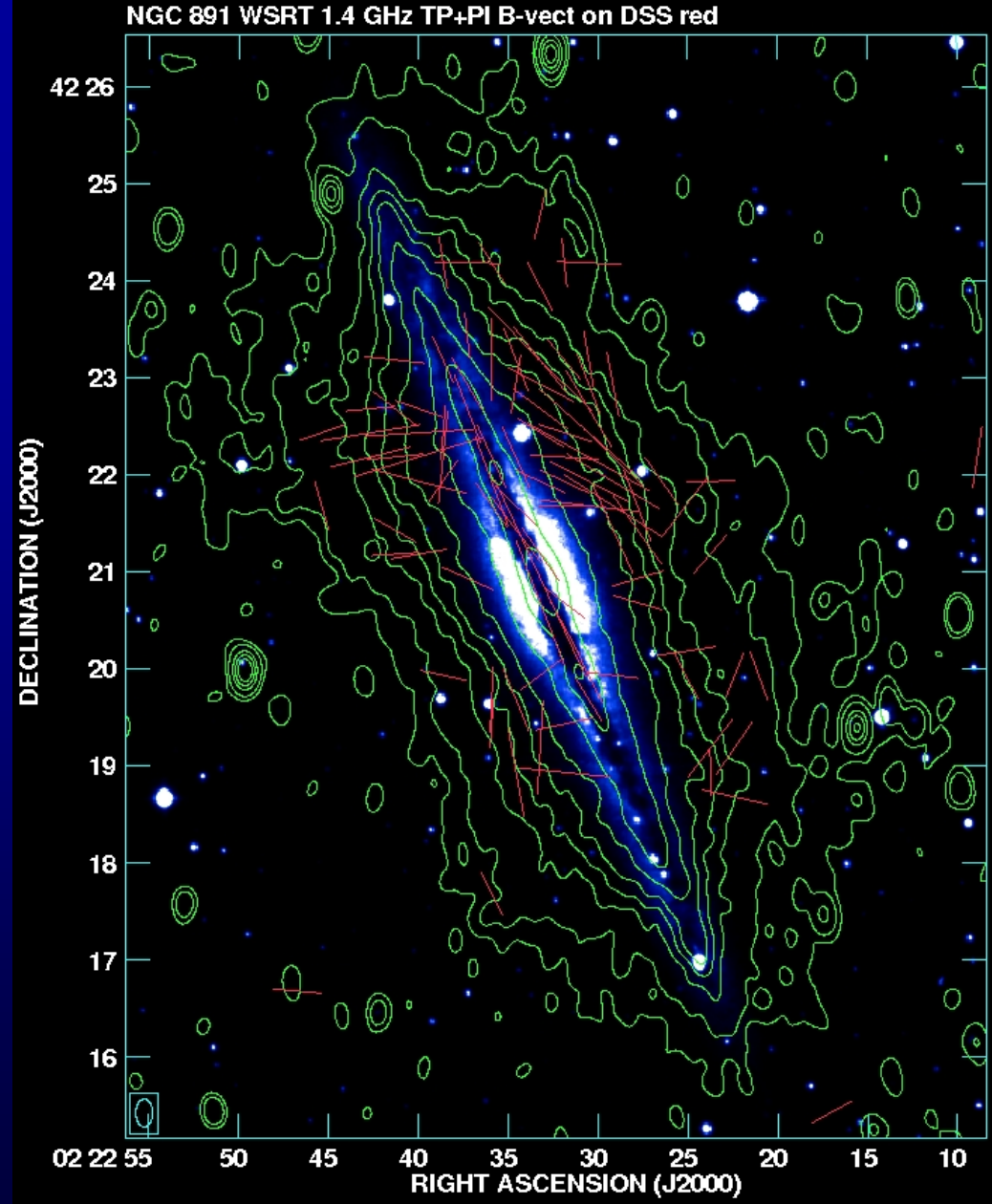
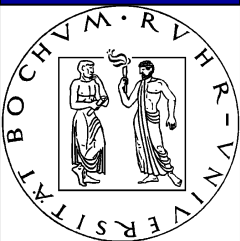
Ralf-Jürgen Dettmar @ MFPO2010

May 18, 2010

NGC891

Adebahr et al.

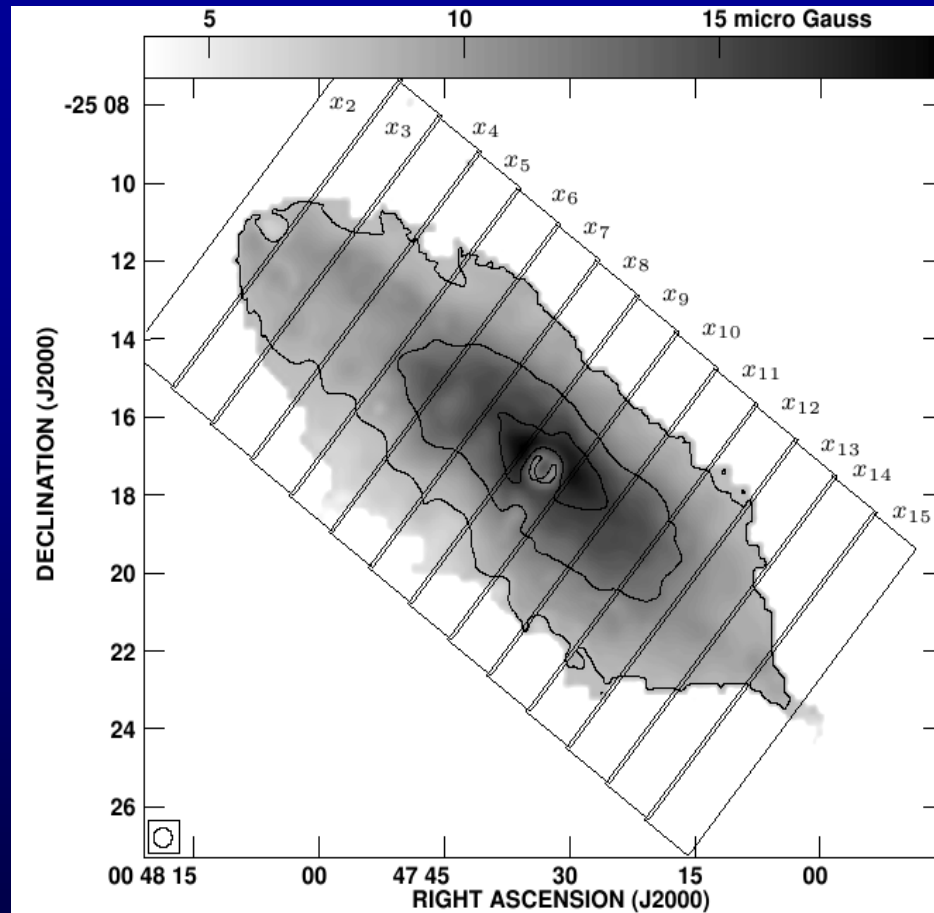
Poster!



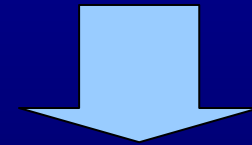
Magnetized halos of spiral galaxies

Ralf-Jürgen Dettmar @ MFPO2010

Total magnetic field strength



local magnetic field strength



local Synchrotron-lifetime

equipartition magnetic field strength:

$$B \propto L_{\nu}^{1/(3+\alpha_{nt})}$$

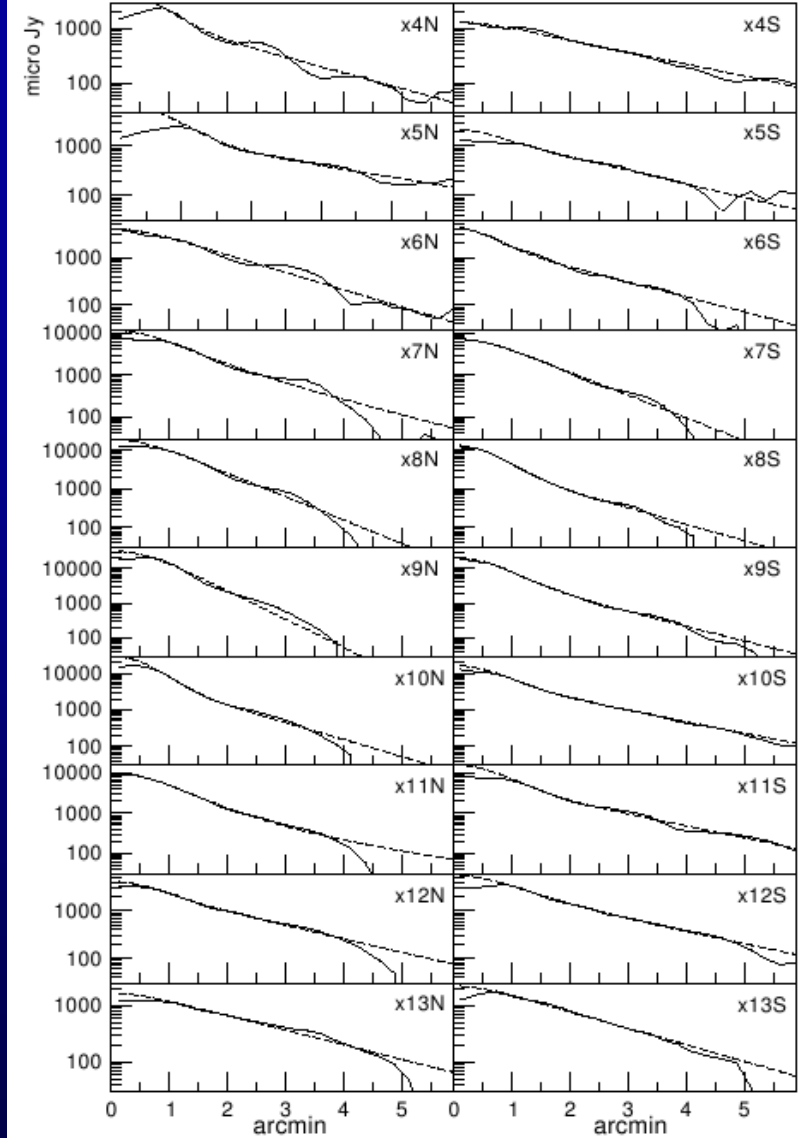
Magnetized halos of spiral galaxies

Ralf-Jürgen Dettmar @ MFPO2010

May 18, 2010



total power emission ↑



Exponential distribution
with scaleheight: h
perpendicular to disk: z
typical scaleheight $\sim$
1.7 kpc

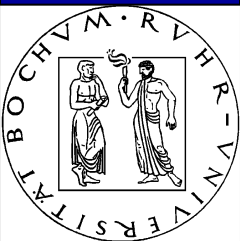
VLA: 6.2 cm

distance from the major axis: z

Magnetized halos of spiral galaxies

Ralf-Jürgen Dettmar @ MFPO2010

May 18, 2010



cosmic ray propagation speed (bulk speed):

$$v_e = \frac{3 + \alpha_{nt}}{2} \frac{\Delta h_e}{\Delta t_{syn}}$$

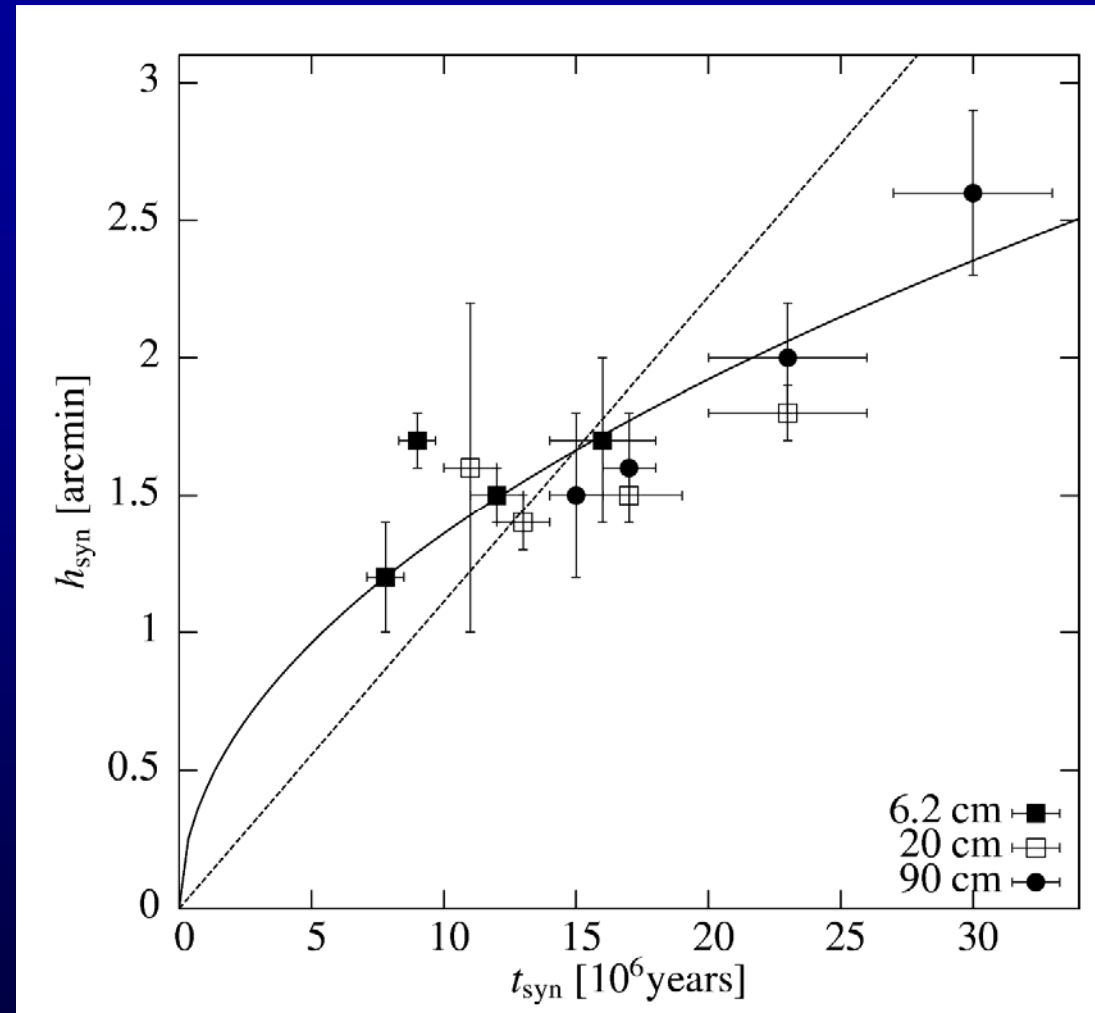
$$v_e \cong (300 \pm 40) km \cdot s^{-1}$$

close to escape velocity!



Scaleheight vs. Synchrotron- lifetime

total power scaleheight



Synchrotron-lifetime

VLA + Effelsberg 6.2 cm



Magnetized halos of spiral galaxies

Ralf-Jürgen Dettmar @ MFPO2010

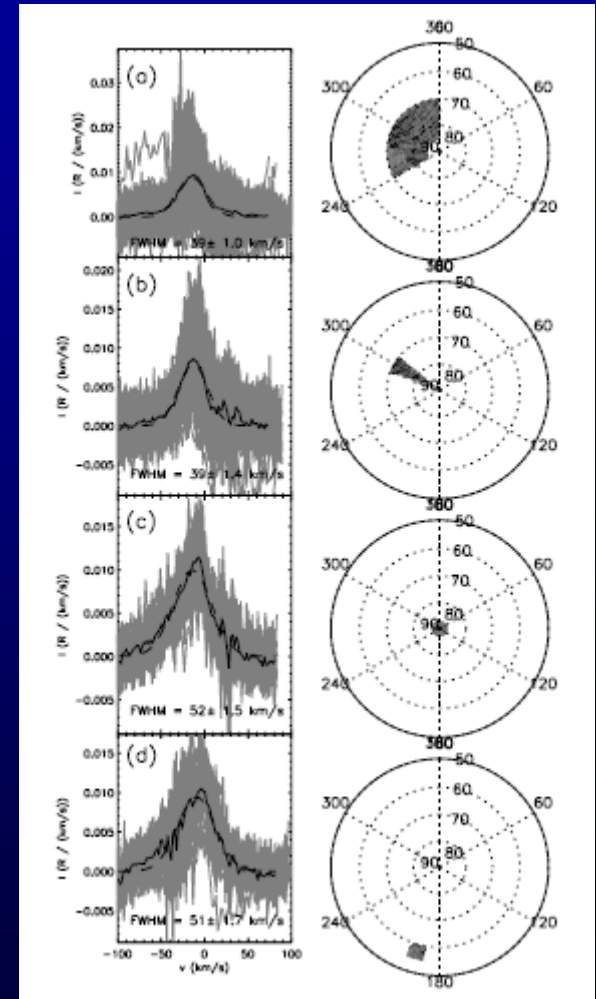
May 18, 2010

“mean velocity” of the rising gas?

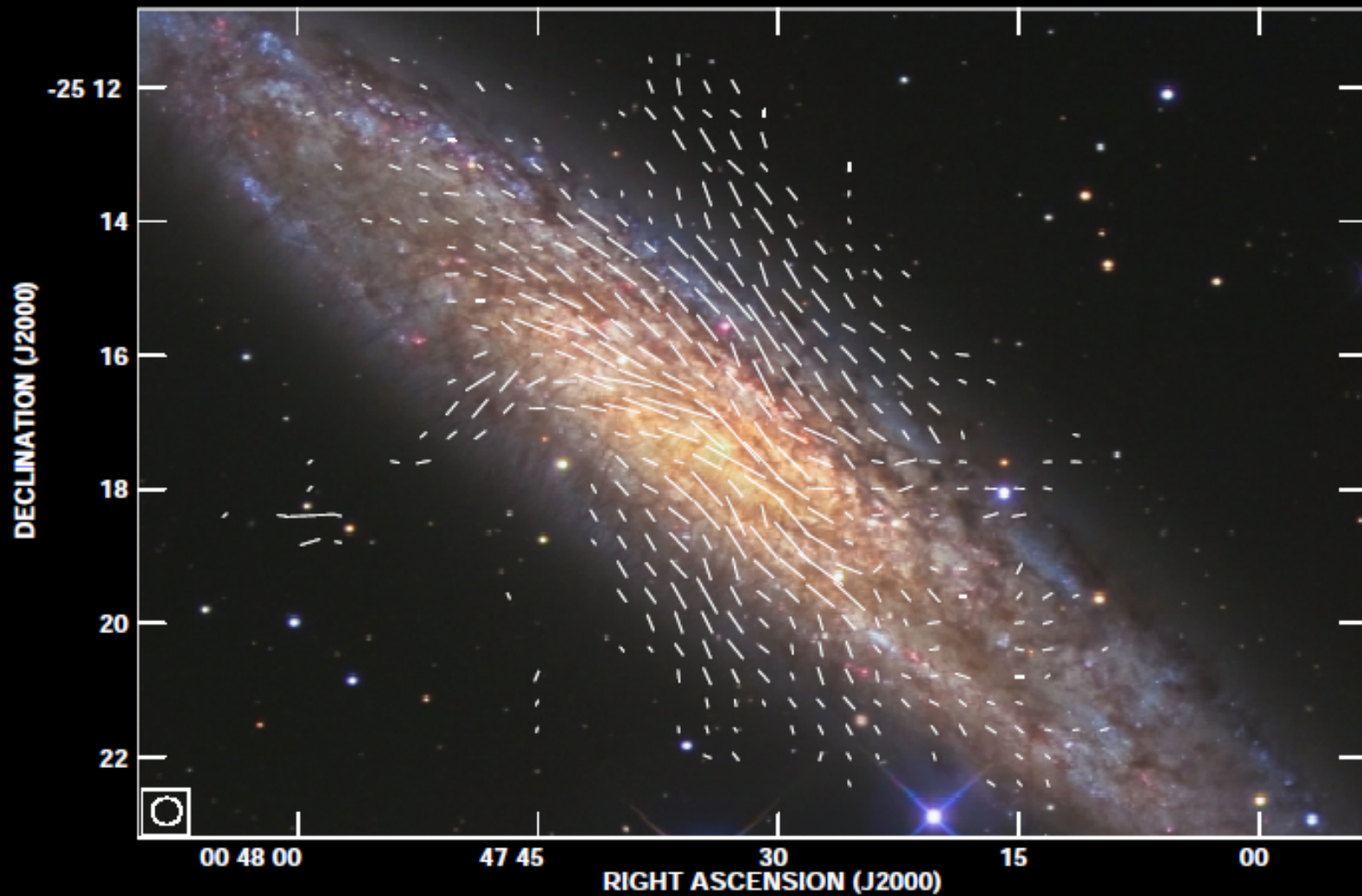
“mass loaded” velocity

using WHAM survey

Hill, Benjamin, Kowal,
Reynolds, Haffner, Lazarian
ApJ 686, 363 (2008)



VLA 6cm mosaic (15 pointings)



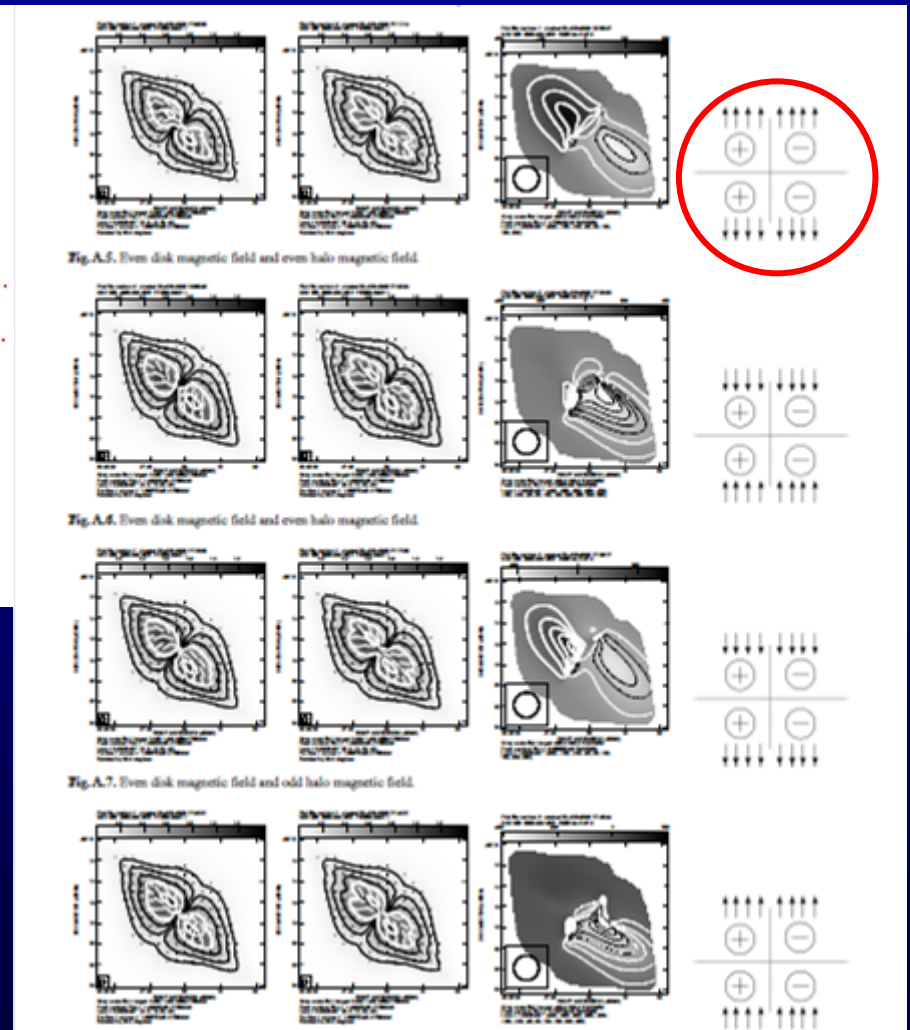
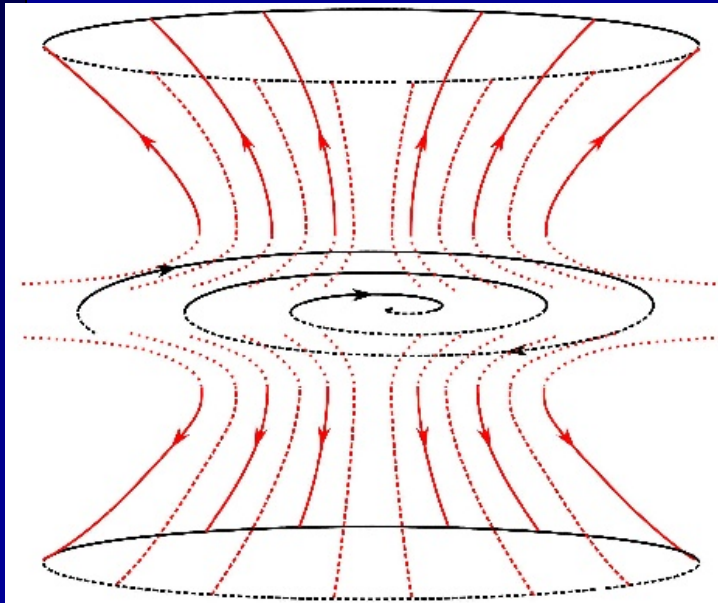
Heesen, PhD thesis and Heesen et al. 2009



Magnetized halos of spiral galaxies

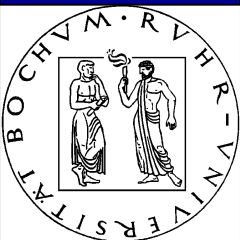
Ralf-Jürgen Dettmar @ MFPO2010

Magnetic field structure from rotation measure analysis



two component model for B

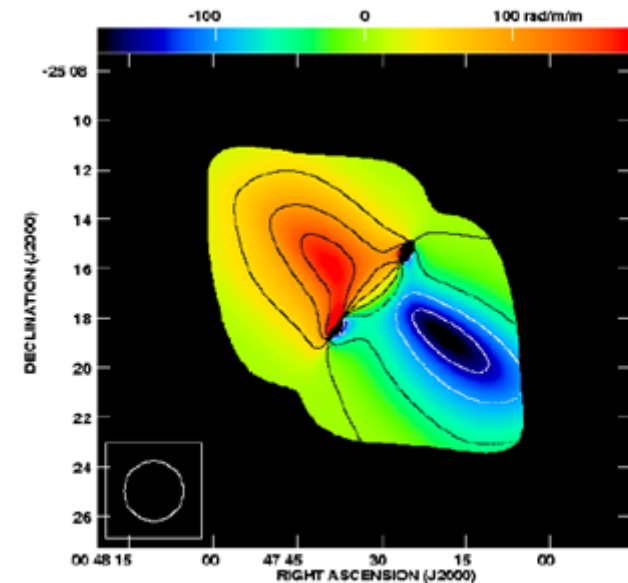
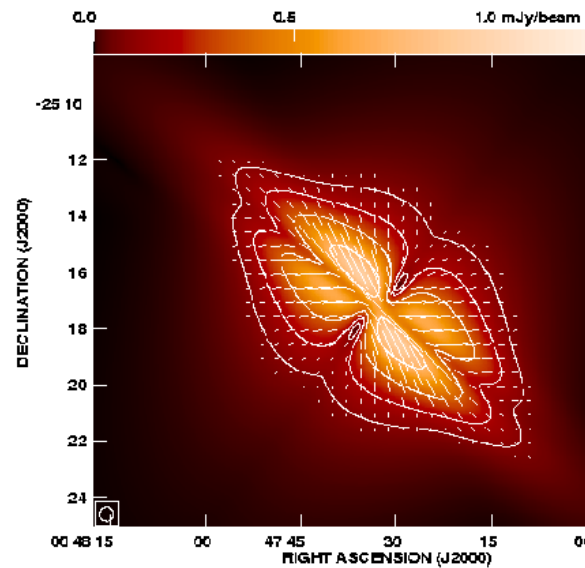
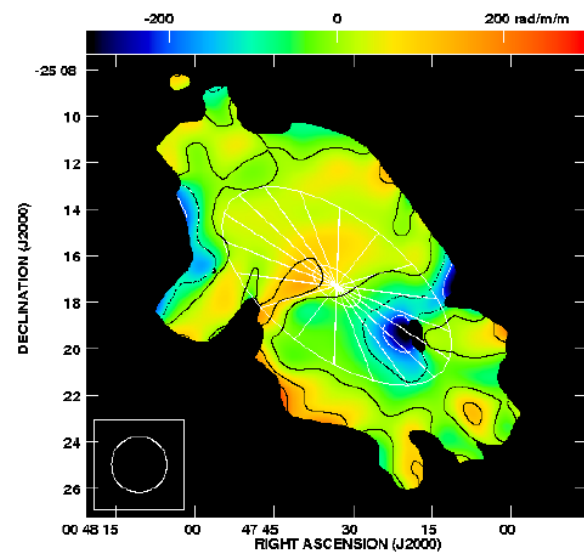
Heesen, Krause, Beck, Dettmar
2009 A&A

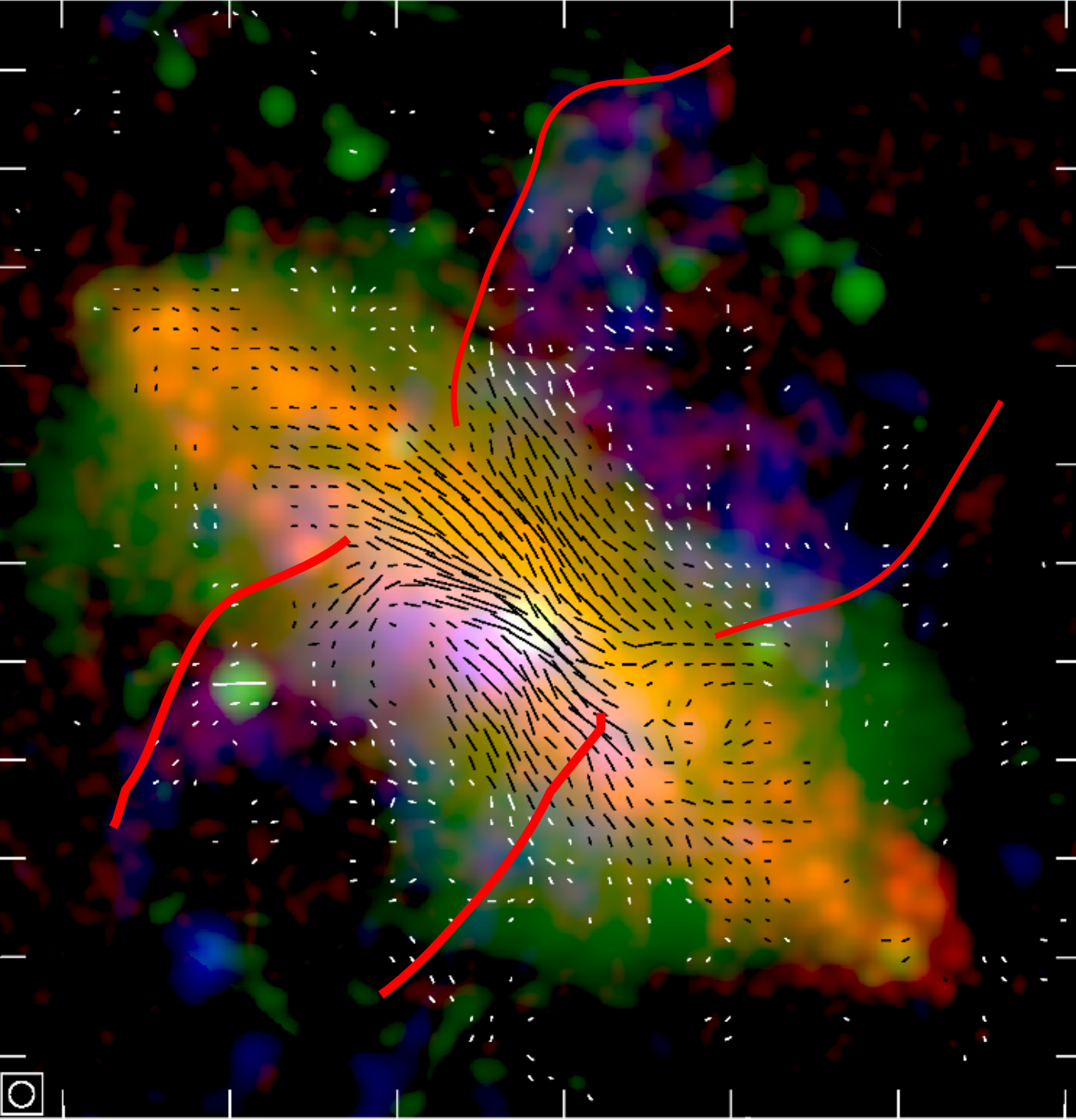


Magnetized halos of spiral galaxies

Ralf-Jürgen Dettmar @ MFPO2010

Magnetic field structure from rotation measure analysis





Red: H α
Green: VLA 6.2
cm total power
Blue: ROSAT
(soft X-ray)
B-vectors VLA
6.2 cm

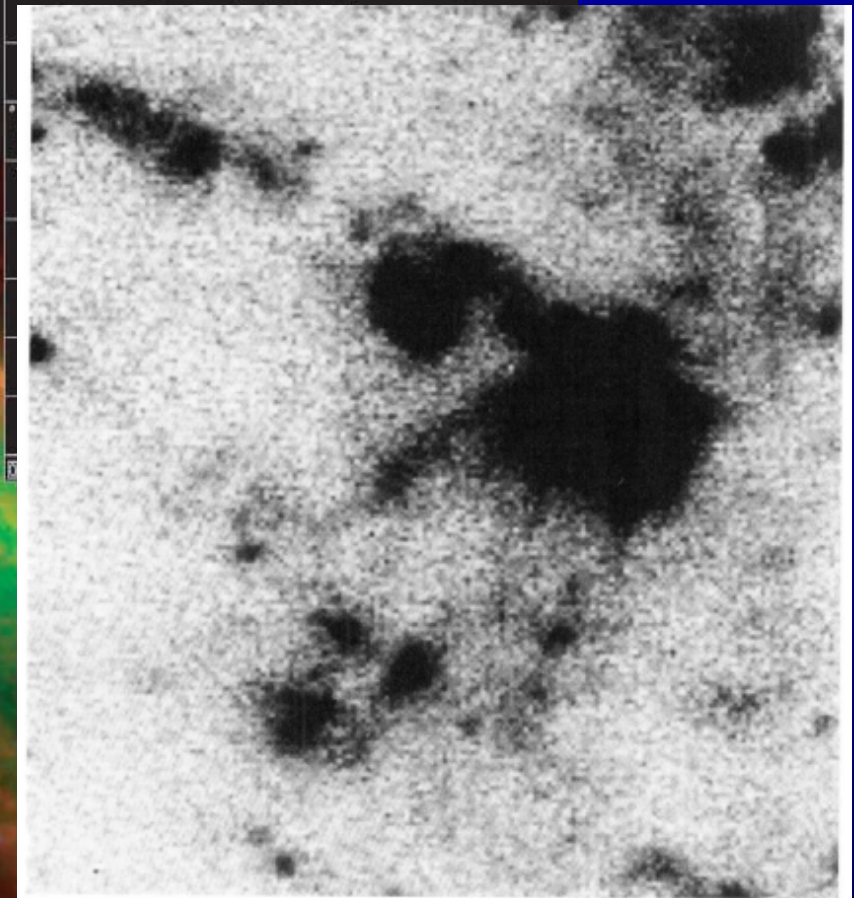
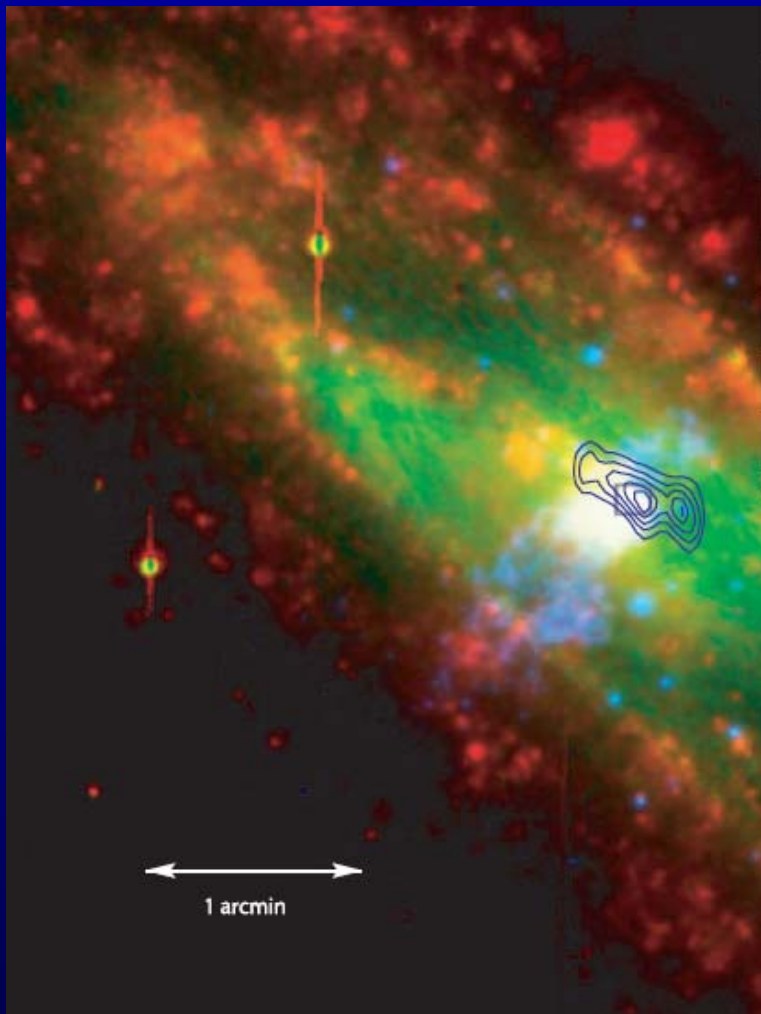


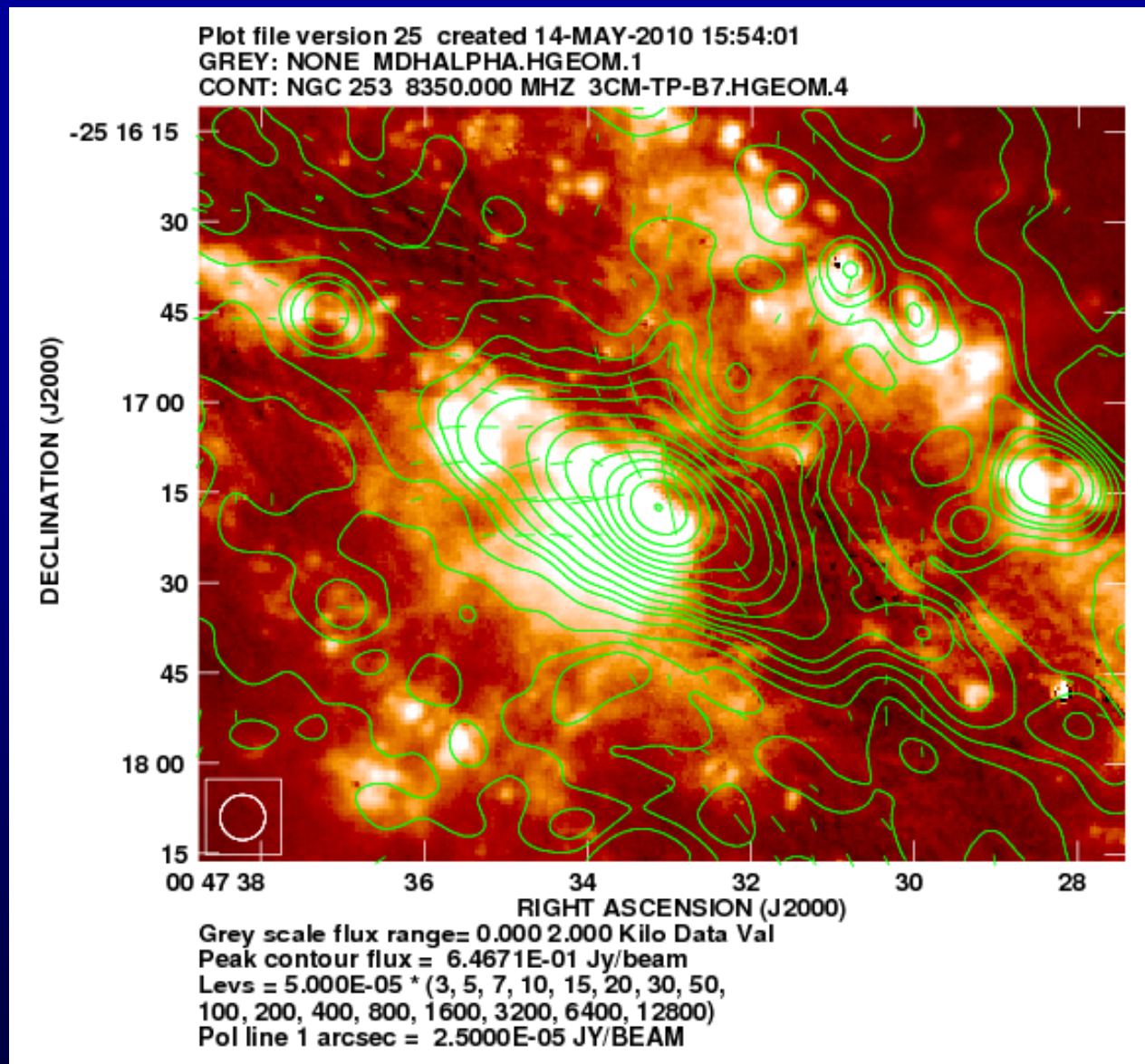
Fig. 1b. Gray-scale representation of the central (240×220 pixel corresponding to $151'' \times 139''$) showing the H α "fan"

Lenc & Tingay AJ 132

Schulz & Wegner A&A (1990)

Magnetized halos of spiral galaxies

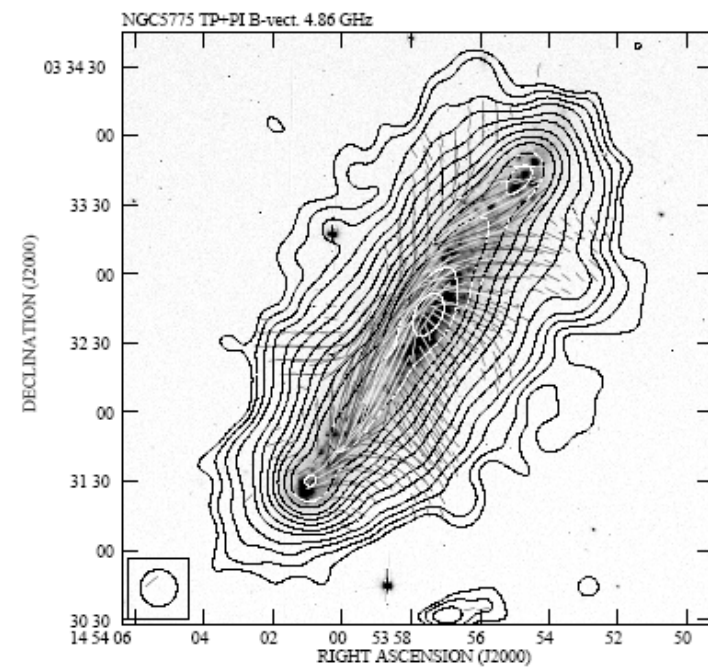
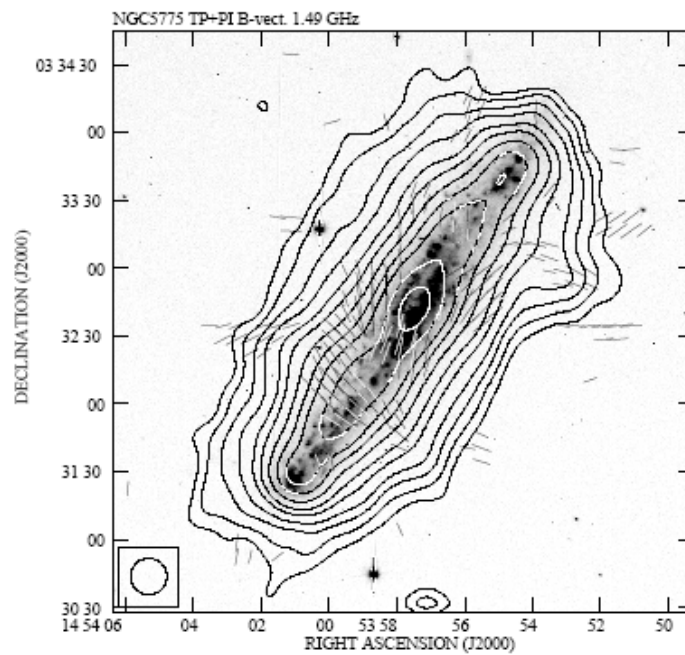
Ralf-Jürgen Dettmar @ MFPO2010



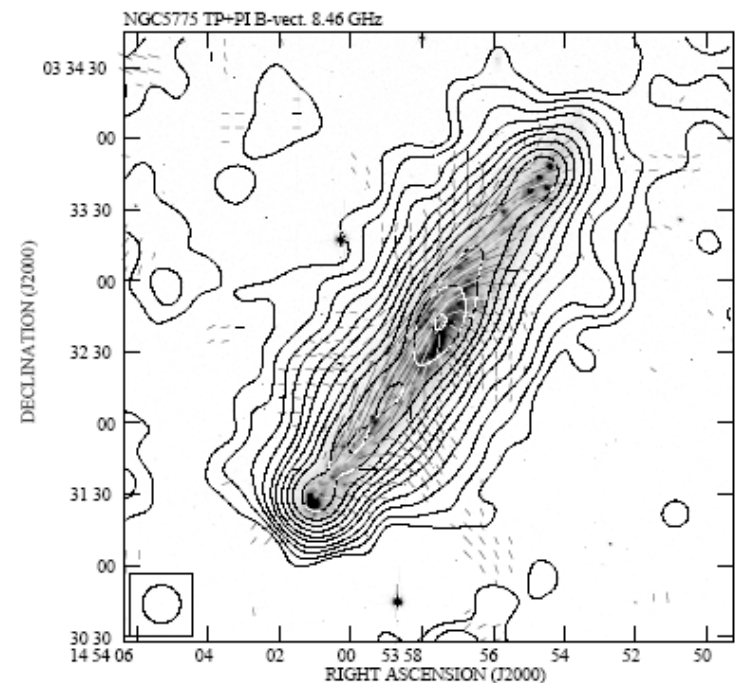
Heesen et al.

Magnetized halos of spiral galaxies

Ralf-Jürgen Dettmar @ MFPO2010



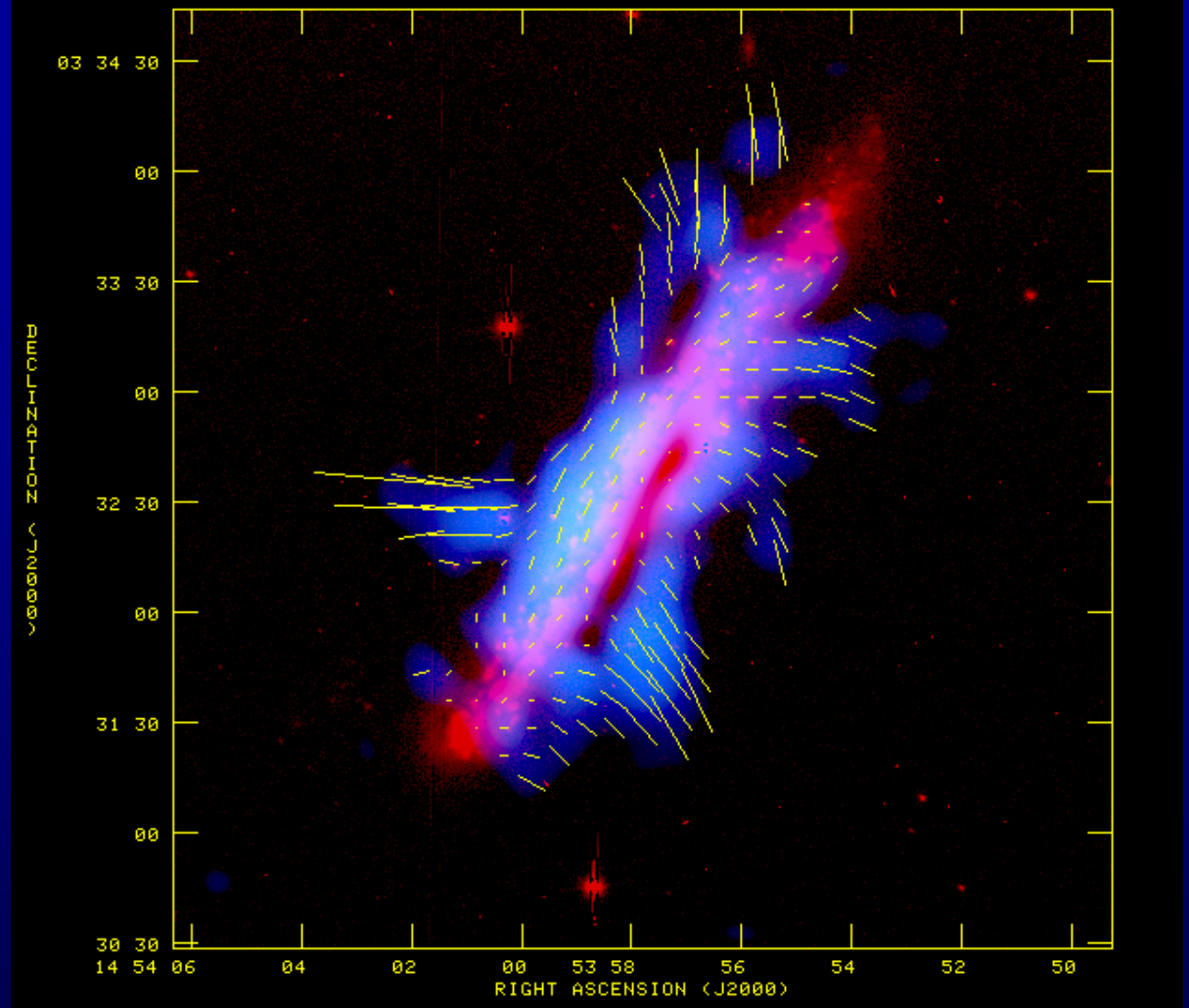
Soida et al. A&A submitted



Magnetized halos of spiral galaxies

Ralf-Jürgen Dettmar @ MFPO2010

NGC5775



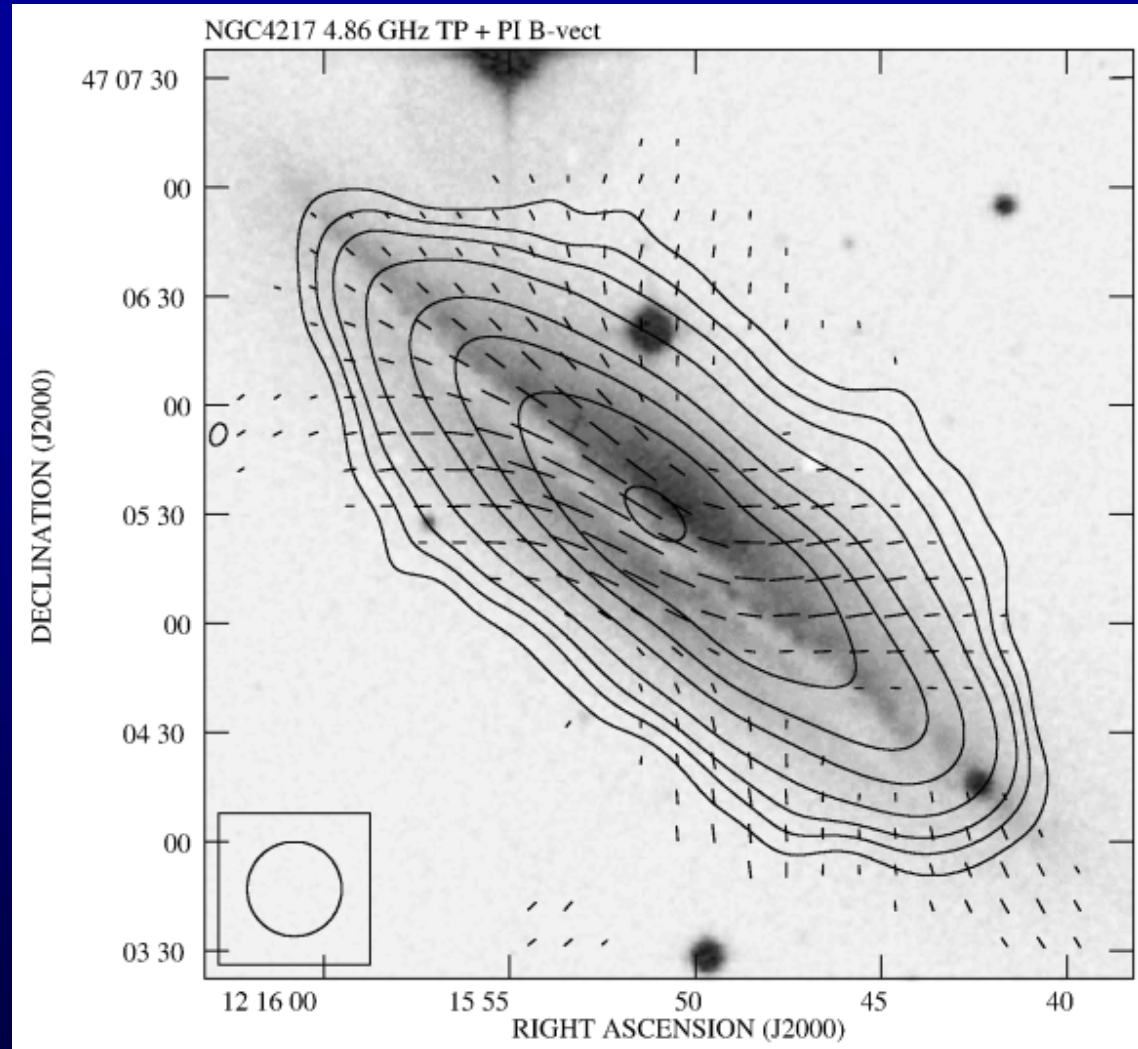
Tüllmann et al. 2000

Magnetized halos of spiral galaxies

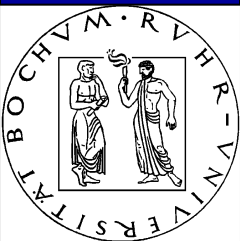
Ralf-Jürgen Dettmar @ MFPO2010

large scale magnetic field structure in halos

the global
magnetic fields
in disk galaxies
typically have a
significant
poloidal
component
(based now on
6+ cases
studied)



Soida & Dettmar AN 2006

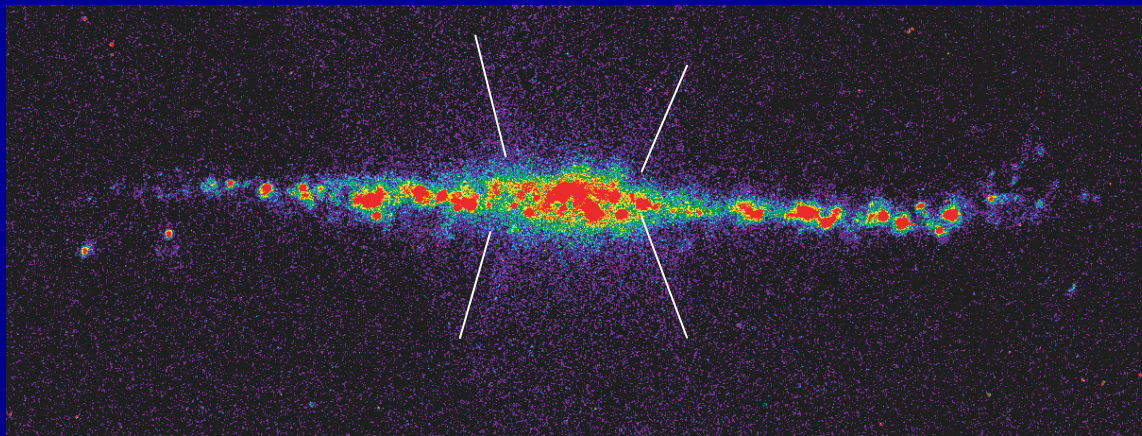


Magnetized halos of spiral galaxies

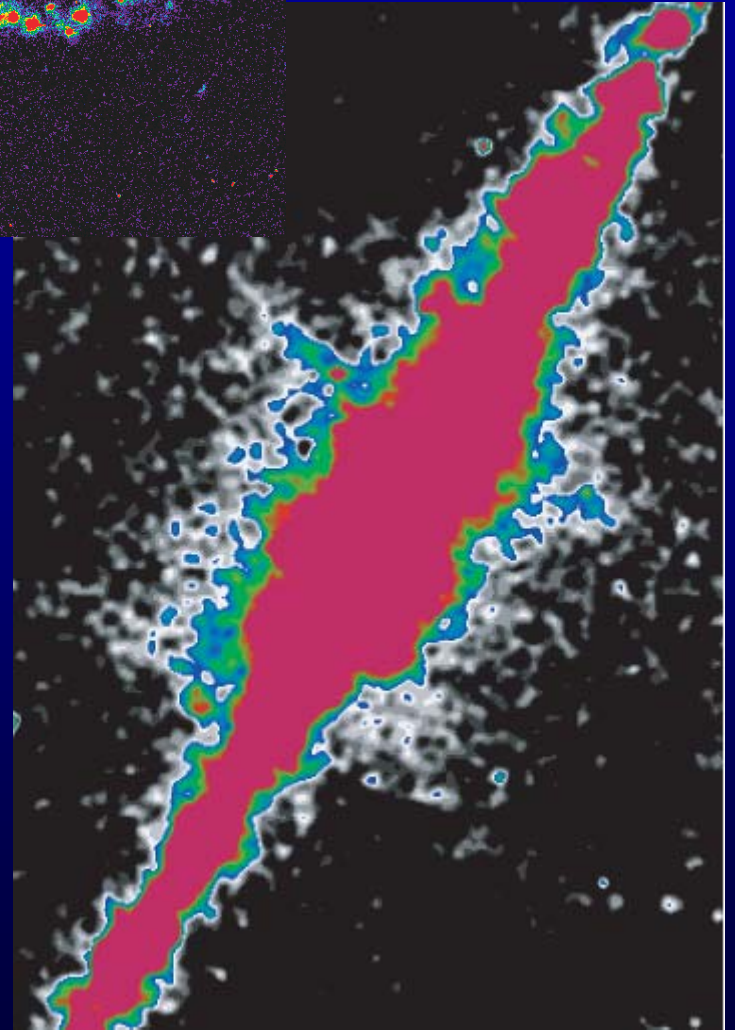
Ralf-Jürgen Dettmar @ MFPO2010

30

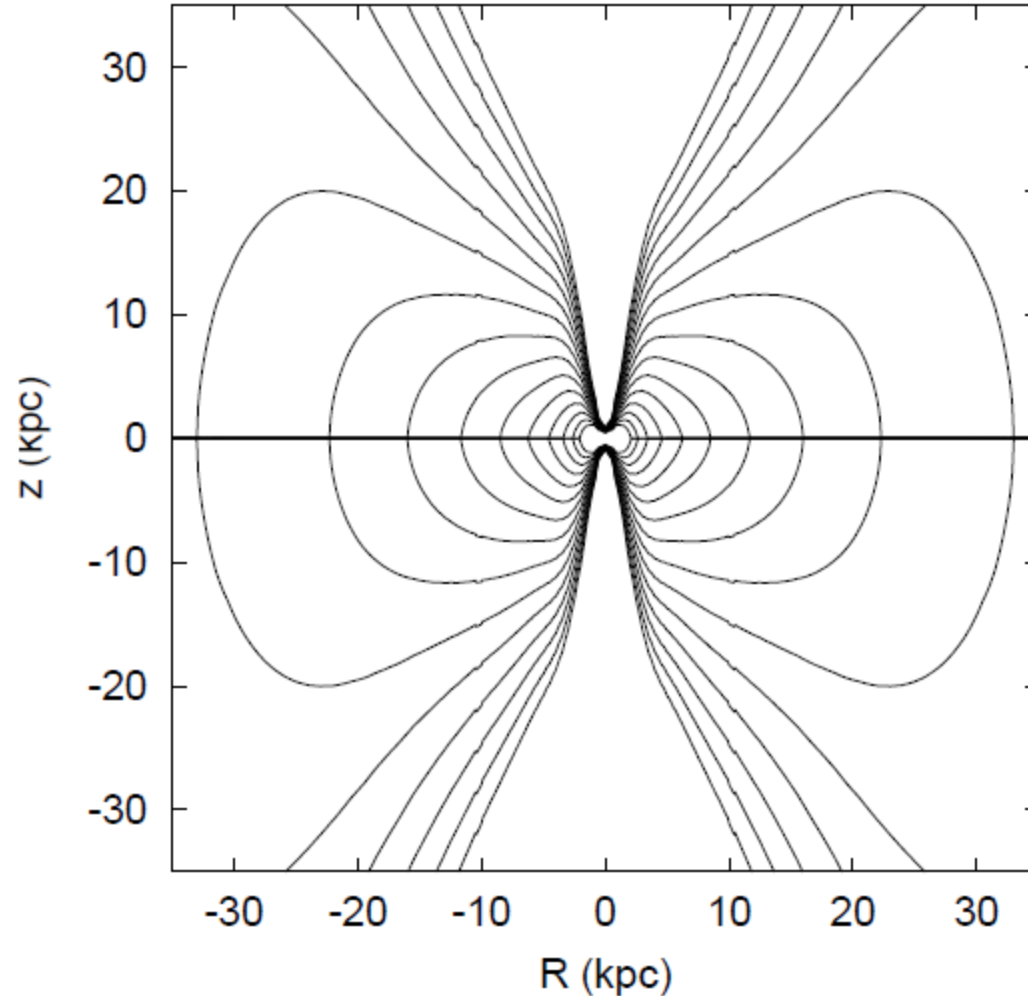
May 18, 2010



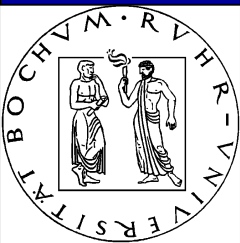
UGC 10043 in $H\alpha$
 Matthews & de Grijs
 AJ 128, 137



Galactic gravitational potential



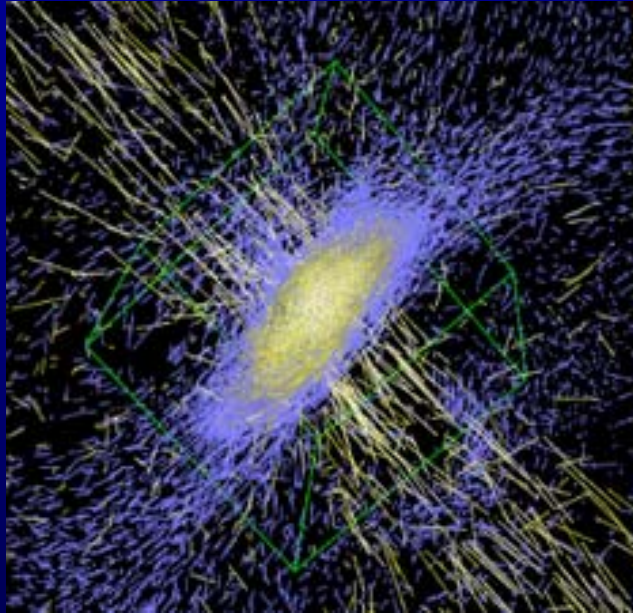
Kalberla ApJ 588 (2003)



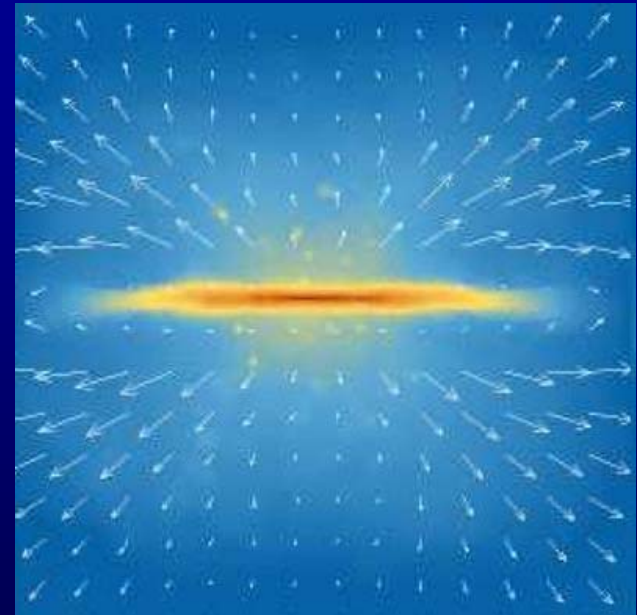
Magnetized halos of spiral galaxies

Ralf-Jürgen Dettmar @ MFPO2010

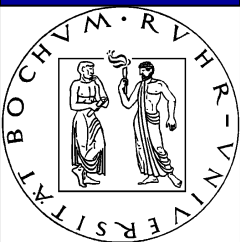
Do galactic winds play a role?



Springel/MPA



Dalla Vecchia & Schaye/Leiden



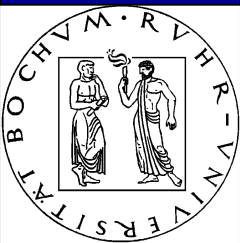
Take home messages:

- the presence of gas in halos incl. cosmic rays and magnetic fields is correlated with the star formation in the underlying disk
- the large scale structure of magnetic fields in halos has a significant poloidal component
- cosmic ray transport in the disk reaches escape velocity => wind?



The End

The work at Ruhr-University Bochum in this area
is supported by DFG, DLR, and BMBF/DESY-PT



Magnetized halos of spiral galaxies

Ralf-Jürgen Dettmar @ MFPO2010